THE ENGINEER

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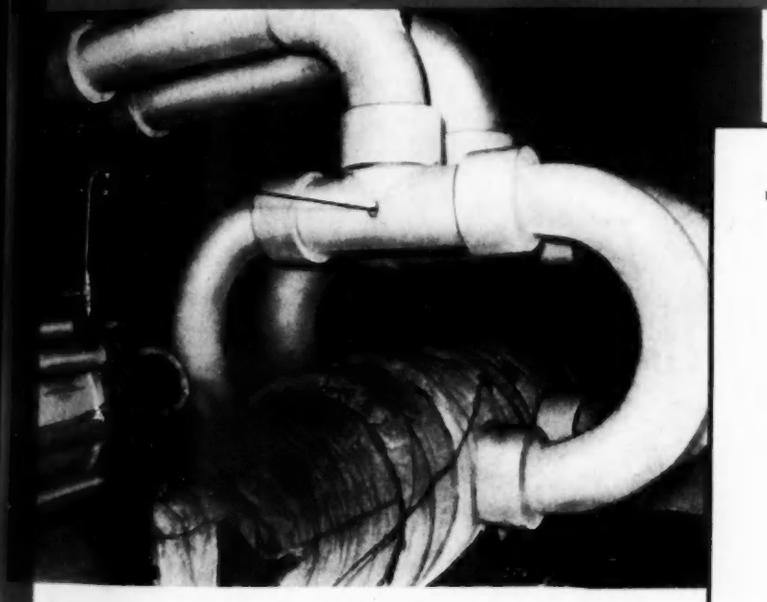

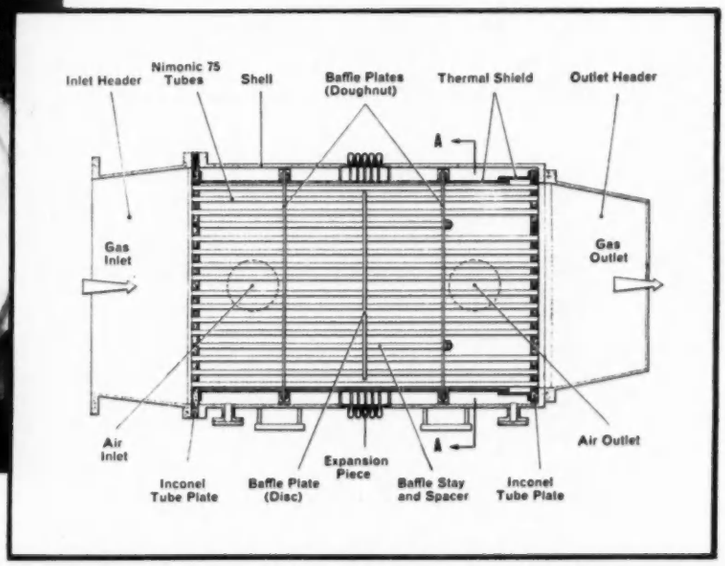

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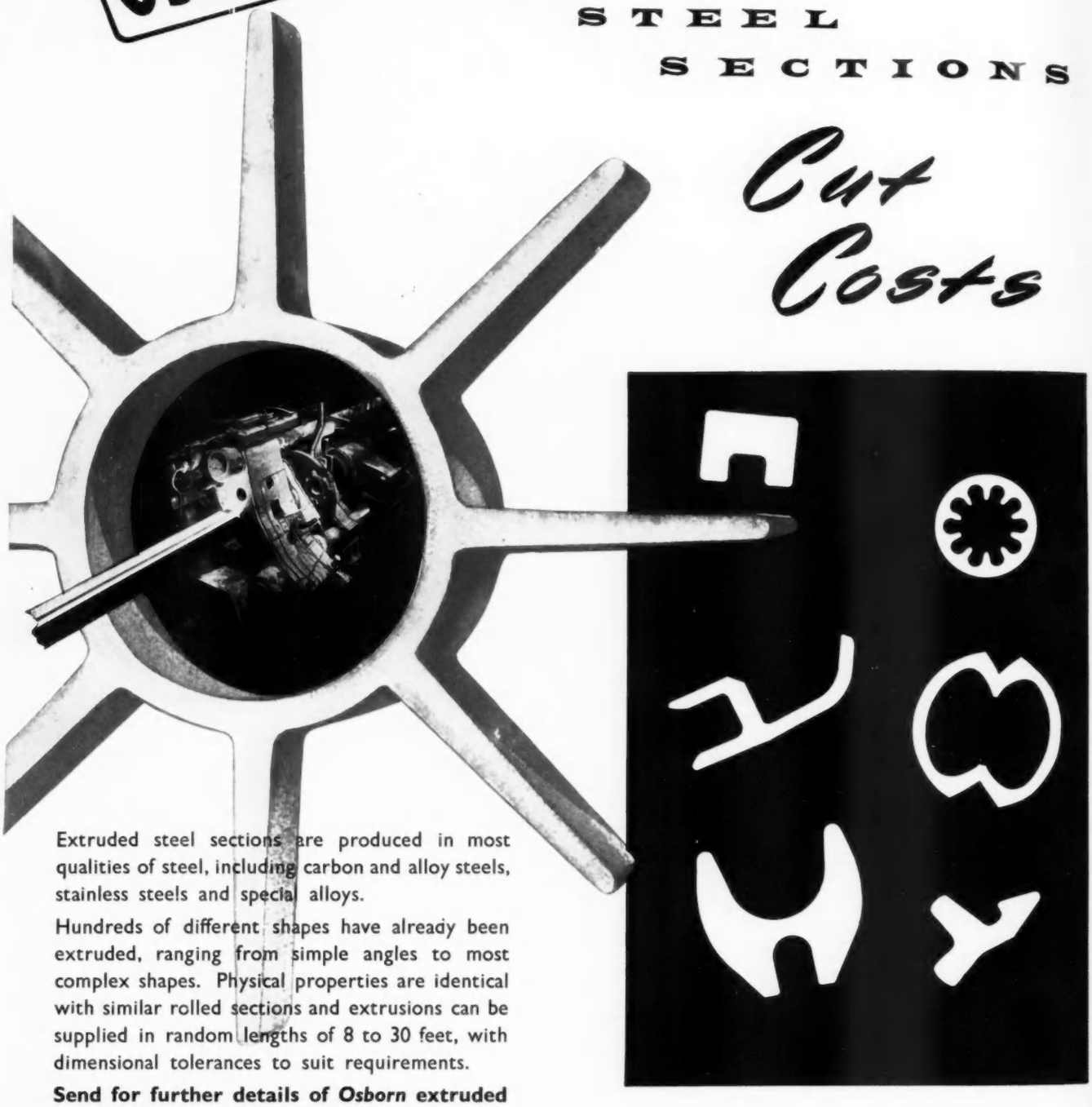

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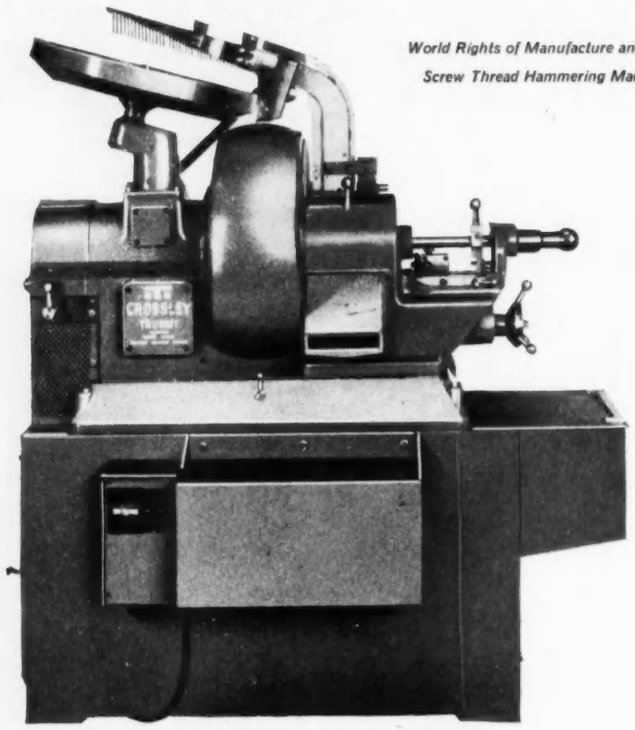

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THE ENGINEER

No. 5500 JUNE 23, 1961 Vol. 211

ELECTRICAL MANUFACTURING

Some of the problems inherent in the expansion of the British electrical manufacturing industry since the war were discussed by Mr. Stanley Steward, director of BEAMA in his paper to the British Electrical Power Convention last week. The increase of output of electrical manufacturers has been more rapid than that of any other major industry. As shown in the extracts from Mr. Steward's paper (page 1023 of this issue), taking 100 as the figure for the Board of Trade index of production in 1948, the corresponding figures for 1960 were: electrical manufacturing 229, vehicles 226, chemicals 213, and all manufactured products lumped together, 159. The cost of this achievement by the electrical manufacturing industry, measured in terms of capital expenditure, has been very considerable, the annual investment having increased by 220 per cent between 1950 and 1959, whereas the corresponding figure averaged for all manufacturing industries was only 85 per cent. Published trading results of the larger electrical manufacturing firms indicate, generally, that earnings during this period have not grown to anything like the same extent as the capital needed to produce them.

The reasons for this state of affairs are given in Mr. Steward's paper. They are best summarised in the statement that heavy capital investment is needed to maintain technical leadership and that keenly competitive trading conditions have narrowed profit margins. In this connection it is worth stressing that electrical manufacture is the largest industrial employer of both scientists and technicians and that progress in electronics and nuclear power will substantially increase the demand for these categories of qualified staff. The present trend is indicated by the fact that, between 1955 and 1958, the electrical manufacturing industry nearly doubled its direct annual expenditure on research.

It can be accepted as axiomatic that the success of this rapidly expanding industry in conditions of sharpening competition at home and abroad depend on "the continuance of a large capital investment programme and a substantial expenditure on research." But many of the larger firms in the industry are faced with the dilemma of how to attract capital for development at a time when yields are low. The difficulties are most marked in the case of the heavy plant manufacturers who must inevitably wait some time before they can expect to see an adequate return on the outlays made for developing the very large generating units up to 550MW and the associated substation equipment. Moreover these returns depend entirely upon a continued exponential growth of the electricity supply system. One solution is to continue the trend towards grouping of individual firms with similar or complementary interests. As far as research is concerned the best prospect of making economies is through increased collaboration. In fundamental research, involving new materials and new techniques, an ideal medium for co-operative effort already exists in the shape of the Electrical Research Association which, with its fine record of past achievements, its new, streamlined, committee structure and its solid links with both the supply and manufacturing sides of the industry, is well equipped for the task. Similarly, the most economical way of tackling research problems of common interest in mechanical engineering might be to enlist the help of existing organisations, such as the Mechanical Engineering Research Laboratory. In following this course there is no need to draw a rigid distinction between pure and applied research, the aim being to keep down the cost of translating research results into engineering practice.

EASTERN REGION ELECTRIC TRAIN FAILURES

In concluding his interim report, published in January, on the Glasgow electric train accidents, Brigadier C. A. Langley referred to the failures in a.c. traction equipments on some London suburban lines of the Eastern Region which had necessitated reductions of service. A second interim report on both these series of occurrences has now appeared,* and is concerned mainly with those in North East London. A summary appears on page 1037 of this issue. The troubles on the North East London trains occurred on sections electrified at 6·25kV and have been experienced in transformers, traction motors, rectifiers and battery chargers. The trains, equipped by The General Electric Company Ltd., were described in our October 21, 1960, issue. In all the transformers affected there was some movement of tap connections, in one case the insulation had been abraded sufficiently to cause a short circuit, and there were sometimes signs of turns displacement in secondary windings. Here, as in the Glasgow trains, rectifier backfires are said to have imposed onerous conditions, but whereas in Glasgow the backfires were attributed to defects in ventilation and control gear, on the Eastern Region most of the rectifiers which failed had lost vacuum, and air or cooling water had entered the cylinders through cracks in the steel anodes. The Glasgow and London troubles have thus both had ingredients which cannot be attributed specifically to the high-voltage 50 c/s system of elecrification. In London, on the other hand, the traction motor failures are associated with the system rather than the machines. Mr. E. L. E. Wheatcroft, a partner of Messrs. Merz and McLellan, has said in a report to the Chief Electrical Engineer of the British Transport Commission on his firm's investigations that their studies have revealed "no reasons to suspect the design or workmanship of the traction motors, and it has now been definitely established that the traction motors were damaged by fault currents resulting from breakdown of the insulation of the windings by switching over-voltages." The conclusion is accepted by Brigadier Langley.

The most severe over-voltages have occurred when a motor coach circuit-breaker has opened during a period when temporary loss of excitation on some rectifiers

*Second Interim Report on the Accidents and Failures which occurred in Multiple Unit Electric Trains in the Scottish Region and Eastern Region, British Railways. H.M.S.O. Price 1s. 9d.

has caused half-wave rectification of the supply to the traction motors. Such conditions arose when intermittent loss of contact between pantograph and overhead wire caused excitation of some rectifier igniters to lock out much earlier than that of others; and, secondly, made the circuit breaker trip either on the inrush of magnetising current resulting from repeatedly re-energising the transformer, or other effects of intermittent loss of contact. Under these conditions the discharge of the energy which was trapped by the operation of the circuit breaker in both the d.c. smoothing chokes and the a.c. transformer caused high transient over-voltages to be impressed on the motor windings. These have been much reduced by changing the earth point from the transformer to the motor circuit; additional protection is to be provided in other parts of the secondary circuit, and it is recommended that the present selenium auxiliary rectifiers of the battery chargers, supplied from a tertiary winding, be replaced by others capable of withstanding higher voltage.

With regard to the occurrence of these troubles in 6·25kV operation after freedom from service faults during trial running on 25kV, it is observed that the step-down ratio to the transformer secondary is four times greater on the higher than on the lower voltage. While this must have been appreciated from the beginning by all concerned with introducing a dual-voltage system, evidently its possible effects were underestimated. One recalls the buoyant optimism with which the high-voltage a.c. system was adopted, and in this report one detects remains of it in the comment that although rectifier troubles began during trial running and persisted throughout, "until early in December the contractors did not consider that anything was seriously wrong." Since then very detailed investigations have been made in a test train equipped as a mobile laboratory by the contractors themselves.

Brigadier Langley says the onerous conditions when running on the 6·25kV section of the dual-voltage system indicate the need for more research. There can be no questioning this when the extent of 6·25 kV running likely to be needed on the Liverpool and Manchester to Euston electrification, particularly in the London area, is considered. Again, although voltage change-over switching is not discussed in detail in this report, Brigadier Langley calls for further study of this as well, from which it could be deduced that his final report will survey problems even more diverse than those covered by his two interims. Finally, in calling for vigorous pursuit of simplification in minor equipment and safety devices he underlines a characteristic of present installations which has caused concern to many engineers from the beginning. Solutions to all these difficulties may be found, but it will be hard not to consider them belated.

PROBLEM OF NOTICING THE PROBLEM

In his Unwin Memorial Lecture to the Institution of Civil Engineers from which we print an extract on page 1035 of this issue, Professor Baker listed amongst the kinds of civil engineering researches that needed to be done "those which should be but are not proposed by anyone." We suspect those are the ones more important than any others! For again and again in life it has struck us how easy it is to overlook that a problem exists, let alone formulate a research programme to elucidate it. For years a particular process may be carried out in a particular way with, apparently, results that are entirely satisfactory. It may not occur to anyone that the satisfactory results may not be due to any intrinsic merit of the method but may arise from the fact that nobody thinks of asking more of the process than they know by long experience it can provide! Even something unsatisfactory may be fatalistically accepted. For example out of every dozen taps bought from a certain manufacturer it may be found that two are broken in the first week. Because this is a normal occurrence nobody bothers to inquire whether it is due to carelessness on the part of employees or due to variability in some feature of the design of the taps. We often gain confirmation of the point that the need for research is frequently (we are tempted to write usually) overlooked. How often, for example, does one find on visiting a research laboratory comparatively simple researches being conducted into some process or into the design of some well-known device which one would have supposed had long since been the subject of an investigation. The first reaction is to inquire somewhat acidly whether the laboratory cannot find something better to do; the second, after learning what the work has revealed, is to ask why on earth the work was not done years ago. A minor virtue for any firm which contacts a research laboratory is that, by consequence, it may have its eyes opened to the existence of problems it did not realise were there in its own works. A minor virtue? We wonder! May it not be a major one?

LESSENING PROBABILITY OF INSTITUTION MERGER

Progress of the negotiations for amalgamation of the Institution of Municipal Engineers and the Institution of Civil Engineers will probably be familiar to our readers, as the various stages reached have been noted from time to time in these columns. Last week, at the I.Mun.E. Summer meeting in Brighton, it was arranged that a vote should be taken to decide the matter as far as that Institution was concerned (the I.C.E. is already committed in favour of amalgamation) the previous postal ballot not being acceptable under the I.Mun.E. constitution (see THE ENGINEER Feb. 24 last p. 275). A vote was taken by a show of hands and declared to be 354 "for" and 336 "against" the resolution. This is not final, however, and a poll was then demanded and members at the meeting voted again by ballot. The meeting has again been adjourned, and under these arrangements polling will be held at about fourteen regional centres, to enable all the members not present at Brighton to vote. Mr. Hamilton, the I.Mun.E. president for 1960-61, will attend each of these meetings. No further discussion of the amalgamation proposals will take place at the regional meetings, but a report of the Brighton meeting will be circulated in advance; only polling will take place. The meeting also instructed the I.Mun.E. Council that it would consider a 66⅔ per cent majority necessary for amalgamation to proceed, this figure, it is thought, being the minimum which would be acceptable to the Privy Council. Arrangements are that the vote will be known on July 14.

There seems to have been a hardening of opposition to amalgamation within the I.Mun.E. membership since the postal ballot was taken. The new president, Mr. Melville Richards, has expressed himself against the proposal and has stated "The referendum produced an unsatisfactory majority of 62 per cent and I hope in all circumstances the membership will now reject the whole idea. The field will then be clear for a campaign to

start a federation of professional engineering institutions to speak with one voice for the whole of the engineering profession and not merely for two Institutions. Every one of the Chartered Institutions coming under the protection of such a federation would be able to retain its own identity, administer its own affairs, and enjoy its own charter within the framework of the federation. This seems to me common sense." The idea of a federation has also been championed by the I.Struct.E. president, (as noted in Mr. Richards' address printed in abstract in THE ENGINEER last week). This view seems to be a compromise between the obvious necessity for a simple and easily recognisable authority capable of representing all professional engineers, on the one hand, and of preserving the specialist or parochial traditions of the small groups on the other.

We still have to wait then, for a third vote, before we shall know whether this proposal — a small but positive step towards unifying a fragmented profession — will be adopted or discarded. The existence of a properly organised profession for engineers seems a long way off!

OFF-THE-ROAD LOCOMOTION

The First International Conference on the Mechanics of Soil-Vehicle Systems held last week in Turin and St. Vincent, in Italy, can truly be described as a landmark in the history of engineering. Some 320 delegates from seventeen different countries met to exchange information and ideas on the mechanics of off-the-road locomotion. In particular, the Conference concerned itself with the fundamental relationship between vehicles and the soil on which they operate — which had not been done before at any major gathering. The local, Italian, contingent was, naturally, the largest but the second largest came from the United States and, significantly, was almost as large as all the other non-Italian delegations put together. This fact reflects the interest of the U.S. Army, industry and academic institutions in the mechanics of off-the-road locomotion; it also provides an indication of the effort devoted to this subject in the United States. Further evidence is given by the fact that sixty per cent of the papers submitted to the Conference were by American authors and, what is more, most of its significant contents came from them.

Indeed, the Conference centred on the progress achieved in the United States during the past decade towards a better understanding of soil-vehicle relationships and a less empirical approach to the design of cross-country vehicles. The progress has been considerable, due largely to the analytical methods evolved by M. G. Bekker at the U.S. Army Land Locomotion Research Laboratory. These methods, based logically on studies of soil properties, enable reasonably accurate predictions to be made of vehicle performance in any given terrain whose physical characteristics are known. There is room for considerable further improvement in "methodology" and, especially, in the statistical analysis of the properties of terrain, which vary in space and time. However, the existing methods have already been successfully used in design investigations by the U.S. Army Ordnance Tank-Automotive Command.

It is already clear that these studies will, as would be hoped, result in economies: in doing a given task more cheaply, or in deploying the available resources more effectively. These are objects very dear to, particularly, the customers of the British motor industry and it is, to say the least, disappointing to find that there were represented at the Conference only two British vehicle makers, one specialising in agricultural machinery, while the fighting services of the Commonwealth sent but three delegates, one from Britain and two from Canada.

CONSTRUCTIONAL PLANT ON SHOW

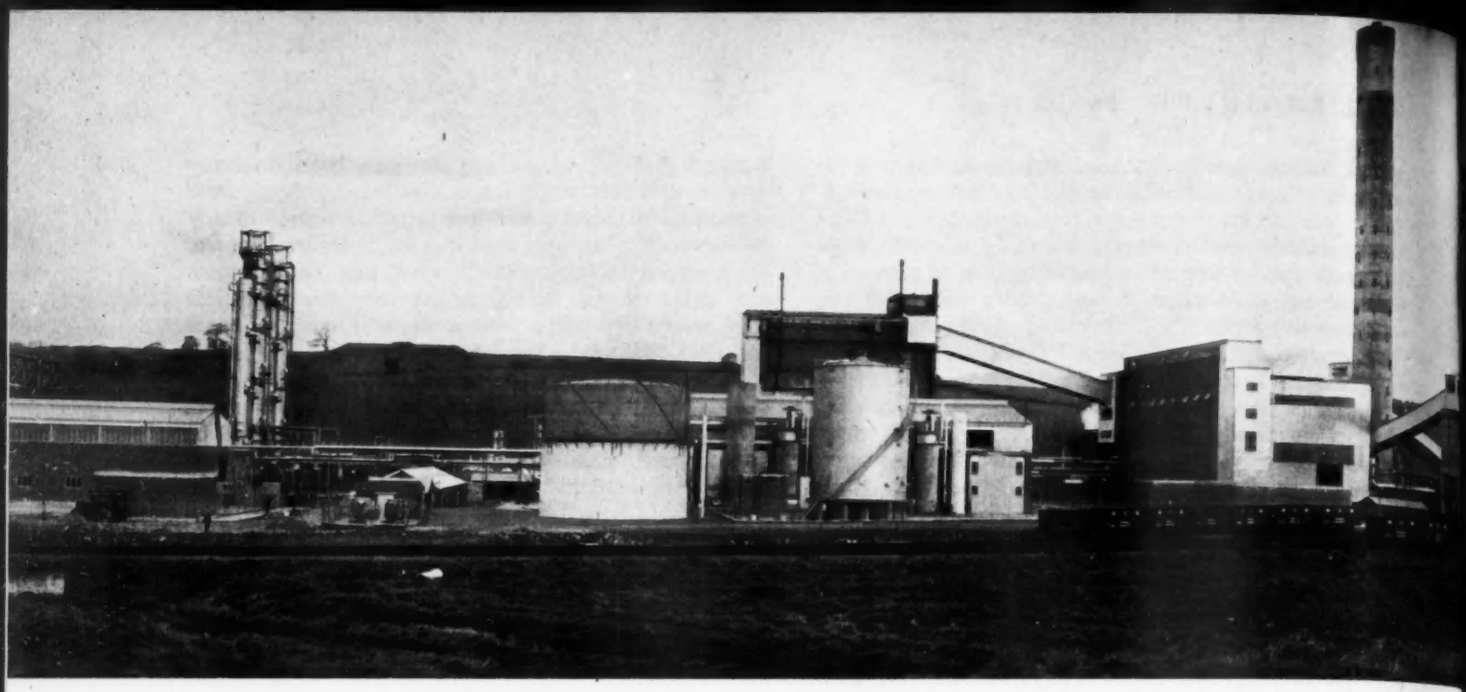
Exhibitions of engineering "hardware" of all kinds are becoming more numerous and elaborate, and there are probably many engineers who will look with a jaundiced eye on yet another one. Even so, the latest of such shows, the International Construction Equipment Exhibition, seems by all accounts to be very successful in conception although we understand attendance in the first week has been poorer than expected. The array of constructional plant of all kinds to be seen at Crystal Palace is indeed impressive, and was described by Mr. Maudling at the opening as "truly magnificent". Part of its success is clearly due to the excellence of the Crystal Palace site with its fine views and spaciousness, and on this occasion, its two proving grounds. This makes the exhibition essentially a fine weather event, and up to the time of writing, the sun has been obliging, and the rain has kept away! We cannot but ponder, however, on the sort of unofficial competition which might develop if, with deteriorating weather, the proving grounds gradually became wetter, and which firm would win the distinction of keeping its plant at work the longest! Paradoxically, with the most complete array of constructional plant yet gathered in one place in this country, the roads and footways of the exhibition are uneven and shabby. Here was a ready made "proving ground" for coating plant and rollers, which might have been used to great advantage. However, this is the first exhibition to be held at Crystal Palace since the war, so there is hope that the amenities of all kinds will improve in the future.

The Engineer—100 Years Ago (JUNE 21, 1861).

"RAILWAY BONFIRES"

"Years ago, some seventy passengers were burnt to death in a train running on the Paris and Versailles Railway." "Had there been a bell-cord throughout the train, in reach of every passenger, as there now is on many German and on all American trains, the attention of the guards would have been called before the fire had made any considerable headway." "The engineman and guards, gazing steadfastly ahead, can know nothing of what is passing behind them. The imprisoned passengers can neither reach them nor make themselves heard. Yet there is no difficulty in providing means of instant communication. All that is needed is a bell-cord . . ."

"We are able to state upon our own knowledge that such cords work well in trains upwards of 500ft in length, and, indeed, on goods trains a quarter of a mile long. In fact, the chief difference in result between this appliance and the ingenious contrivances frequently patented for a like purpose, to wit: electric signals, universally-coupled shafts, mirrors on the sides of the engine, speaking trumpets, and the never-to-be-forgotten watchman, perched on the rear carriage, who, on the discovery of danger, was to shoot an arrow at a bell on the footplate of the engine(!) the contingency of hitting the engineman's head, or an unhappy pig in a neighbouring paddock, or the moon, or nothing at all, not being taken into account—the chief difference, we say, is, that the bell-cord will 'work,' and the rest will not."



Westfield Works Pressure Gasification Plant

The first stage of the pressure gasification plant at the new Westfield works of the Scottish Gas Board has now been commissioned and the works will be officially opened by Her Majesty the Queen next Tuesday. This plant, costing £6,600,000, *is the first large installation in Britain and is initially delivering* 15,000,000 *cubic feet of gas a day into a new high-pressure grid system in central Scotland. In the second stage, to be completed in a few months, the output of the works will be doubled and it will be capable of producing one-fifth of the present total demand for gas in Scotland.*

AN event of particular interest to the British gas industry has been the completion and commissioning of the initial stage of the first high-pressure gasification Lurgi plant in this country at Westfield in Fife. This plant, built to the requirements of the Scottish Gas Board with Humphries and Glasgow, Ltd., acting as the main contractors and consultants, is to be opened on Tuesday next by Her Majesty the Queen. In its first stage the plant is producing 15,000,000 cubic feet of gas a day and with the completion of the second stage in a few months its daily output will be doubled.

The new works forms an important part of a supergrid gas supply system for Central Scotland and an overall plan for integration of the sources of gas supply. Advantage has been taken of the fact that Lurgi plant produces gas at high pressures and the output is delivered directly into mains designed for a working pressure up to 300 lb per square inch. Under the supergrid scheme 260 miles of high-pressure pipelines are to be laid and the 75 miles completed to date link Westfield with Coatbridge and Newport. When completed the high-pressure lines to be built under the scheme will carry gas to local grid schemes round Glasgow in the west and Perth and Dundee in the north. The 1100 miles of mains entailed will include a supergrid system operating at 250 lb per square inch feeding ordinary grid mains delivering gas at up to 25 lb per square inch to areas. This grid will also be fed with gas from coke ovens and other installations and at some time in the future it will be extended to include Edinburgh and Kilmarnock.

The general layout of the plant at the Westfield works can be seen in the illustration above. The 48 acre site selected for the scheme gave rise to a number of problems in preparation as parts of it are above old flooded mine workings. The top soil was a sponge-like 3ft to 5ft depth of peat moss and site levelling work entailed the excavation of 50,000 tons of this peat moss and soft soil. The work of site preparation also involved the blasting away of spurs of igneous rock near the surface to provide the required foundation levels. To ensure that there would be no chance of damage to heavy sections of the plant as a result of subsidence in the future the foundations have been secured on Franki piles and mass concrete rafts.

An important economic factor in the siting of the new works is the availability of large supplies of a low grade coal from an adjacent open cast working of the National Coal Board. This coal is non-caking in addition to having a high ash and moisture content—which makes it unsuitable for orthodox carbonisation purposes. From the mine washery the coal is delivered by wagon to the gas works in the form of ¼in to 1in washed singles with washed middlings added to give not more than 30 per cent inerts with a maximum of 16 per cent ash in the final mixture.

The coal is delivered on to a conveyor system by which it is raised and deposited into the overhead bunkers of the Lurgi house. Of the four Lurgi gasifiers installed in this house three have been supplied from Germany and the fourth, which will be commissioned in the second stage of the scheme, by the Power Gas Corporation, Ltd. The diagram opposite shows the construction of one of the gasifiers and, as the operating principle of the Lurgi process is now generally known, a detailed description here is unnecessary. Briefly, coal is delivered into the top of the gasifier by an overhead lock hopper and steam and oxygen are introduced at the lower end, the gas being generated as a result of the reaction of steam and oxygen with the coal at a pressure of about 30 atmospheres. A gasifier produces upwards of 7,500,000 cubic feet of gas a day.

Each gasifier comprises a fusion welded vessel 19ft high overall and 10ft outside diameter. The pressure lock at the top of the vessel takes about 5 tons of coal and a charging cycle is carried out at intervals of about twenty minutes. Each sequence of the charging cycle is completed automatically by hydraulically operated equipment controlled by the manual setting of a handwheel by the charging platform attendant. In this sequence the lower cone valve of the lock is raised to seal the chamber from the gasifier and a vent is opened to release the pressure. The top cone valve is then opened and coal gravitates into the lock through a chute from the hopper above. When the lock is full the top valve is closed and the vessel is pressurised with gas before the lower valve is opened to feed coal into the gasifier chamber. A rotating coal distributor in the top of the gasifier maintains a level surface on the fuel bed.

As the coal used at Westfield has slight caking tendencies at the 30 atmospheres pressure in the gasifier there has been fitted a stirring mechanism having rotating water-cooled fingers which cut continuously through the softening coal. This "stirring" action tends to produce a quantity of dust and to reduce this dust carry-over into the gas stream tar is sprayed continuously from above on to the surface of the fuel bed. From the mechanical grate at the bottom of the gasifier the ash drops into a lock vessel through an open cone valve. This ash lock is discharged into a receiving hopper at about half-hourly intervals and like the coal feed lock its hydraulically operated valve and pressurising sequence are manually controlled by an attendent. The ash is continuously drawn from the receiving hopper by a submerged belt conveyor and delivered to a disposal hopper.

A proportioning device through which the steam and oxygen pass to a gasifier maintains a constant steam-to-oxygen ratio, the delivery of which is regulated in accordance with the required output. The anticipated performance of such gasifier shown in the table below

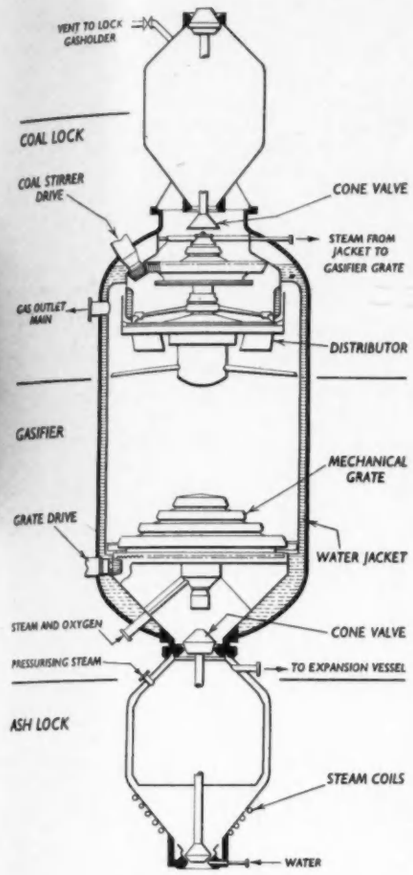


Diagram of Lurgi gasifier

was given in a paper presented by Mr. T. S. Ricketts to the Institution of Gas Engineers last year.

Working pressure of gasifier	355 lb per square inch
Gasification efficiency : (Gross calorific value of gas and by-products divided by gross calorific value of coal to gasifiers)	85 per cent
*Other efficiencies : (i) Gross calorific value of gas and by-products divided by gross calorific value of coal to gasifiers and boilers, including electricity generation	70 per cent
(ii) Gross calorific value of gas only, divided by gross calorific value of coal to gasifiers and boilers, including electricity generation ...	64·6 per cent
†Purified gas output per gasifier to meet normal requirements	7·5 million cu. ft/day
†Purified gas availability per gasifier (based on guarantees)	8·8 million cu. ft/day
†Maximum purified gas availability per gasifier	10·0 million cu. ft/day
†High-pressure steam per 1000 cubic feet of purified gas produced	65 lb
†Oxygen per 1000 cubic feet of purified gas produced	223 cu. ft
High-pressure steam requirements per pound of fuel gasified	1·08 lb
Oxygen requirements per pound of fuel gasified	3·71 cu. ft
Low-pressure waste-heat steam produced per pound of fuel gasified ...	0·86 lb
†Fuel gasified per 1000 cubic feet of purified gas	60·1 lb

* The figures used for coal to boilers in calculating these efficiencies allow only for the direct steam and electricity requirements of the Lurgi gasifiers.

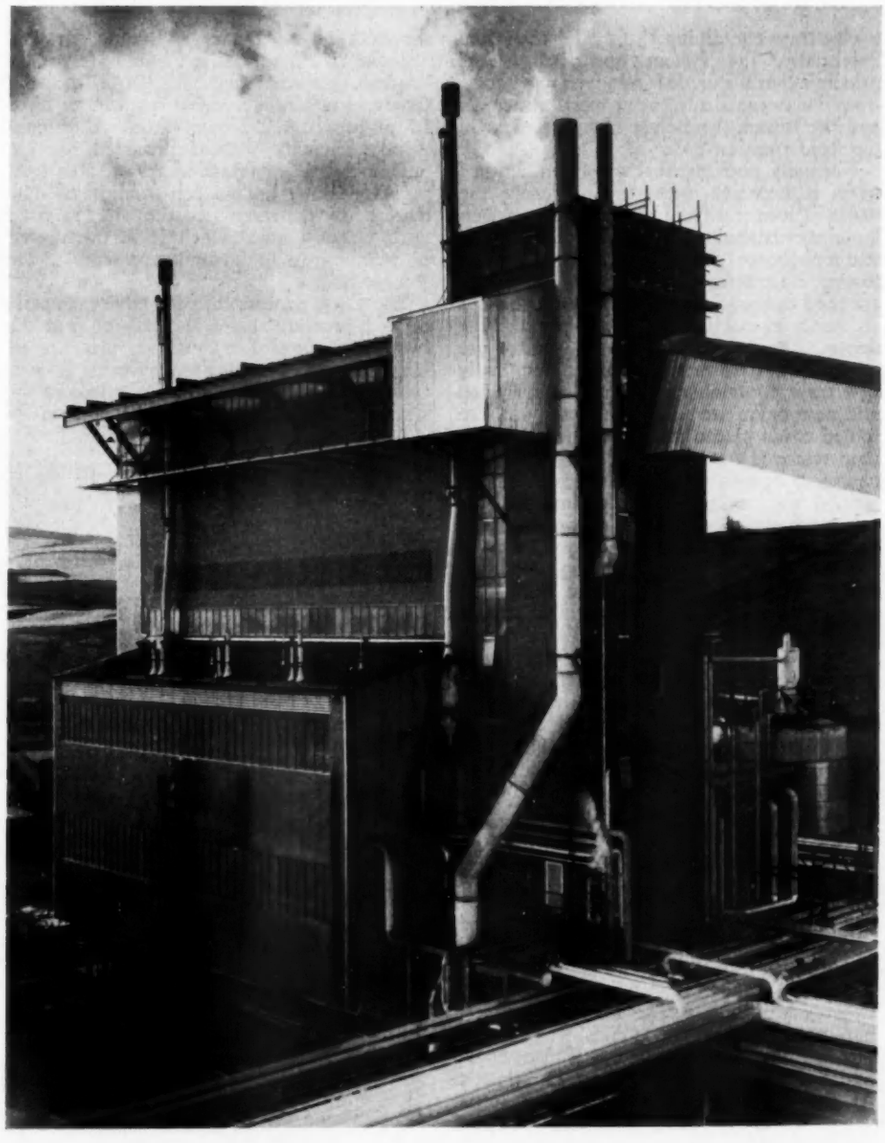
† Assuming 2 per cent of carbon dioxide in purified gas and excluding addition of butane and nitrogen.

Gas leaving the gasifiers at a temperature of 400 deg. to 450 deg. Cent. enters an adjacent quench cooler where it is immediately washed by sprays of tar water and cooled to about 196 deg. Cent. before being passed on to a waste-heat boiler. The large quantities of waste-heat steam obtained in this way are used as process steam in the Benfield plant described later. The gas passes from the boilers to a precooler, and on into a manifold leading to after and final-coolers. After the gas leaves the coolers it passes through various stages of purification. Benzole is removed in two 45ft high absorber towers and in a further stage carbon dioxide and hydrogen sulphide are removed. At Westfield there is used the hot potassium carbonate process in which the simultaneous removal of carbon dioxide and hydrogen sulphide takes place in a Benfield plant. The absorber vessels of this plant are 100ft high by 8ft diameter and the regenerator vessels 120ft high by 10ft 9in diameter.

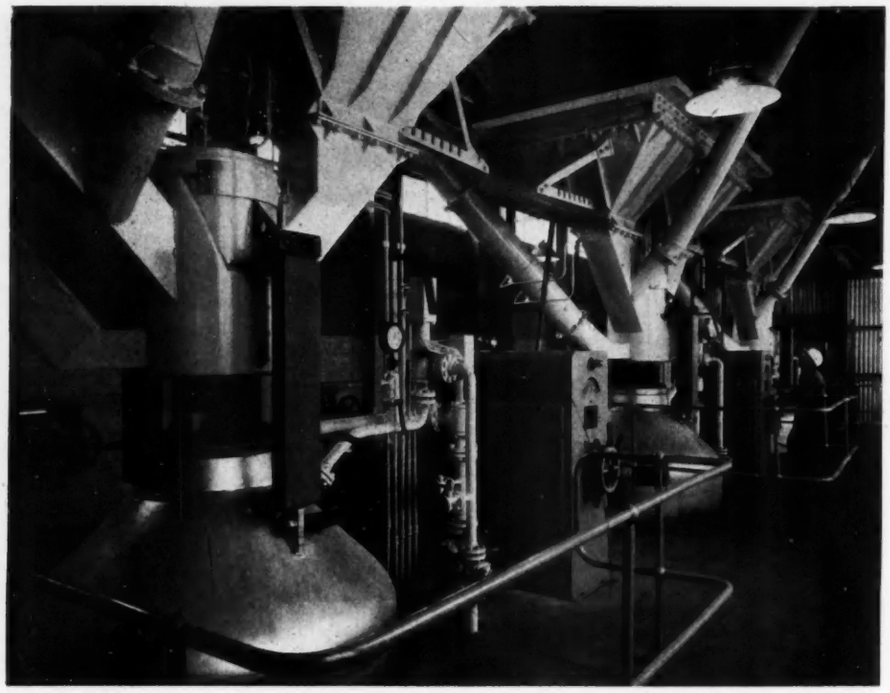
The Lurgi gas when it leaves the coolers has a carbon dioxide content of approximately 27 per cent ; and the hydrogen-sulphide content is about 0·8 per cent. The high carbon-dioxide content must be reduced in view of its effect on the calorific value of the gas. Essentially, the Benfield process involves the absorption of carbon dioxide and hydrogen sulphide in a 35 per cent solution of potassium carbonate at high pressure and at a temperature of approximately 110 deg. Cent. The carbon dioxide and hydrogen sulphide react with the potassium carbonate to form potassium bicarbonate and potassium bisulphide respectively. The solution leaving the absorber, after a reduction of pressure from 325 lb to 5 lb per square inch, passes to a regenerator vessel where conventional steam stripping is carried out at the same temperature.

The acid gases (or waste gases) leaving the top of the regenerator consist of approximately 98 per cent of carbon dioxide and 2 per cent of hydrogen sulphide. After being cooled they pass to a catalytic conversion plant where all hydrogen sulphide is oxidised to sulphur dioxide. The waste gases are then mixed with boiler flue gases and finally pass to the main chimney stack. A plant for the recovery of sulphur from the waste gases being installed by Newton Chambers and Co., Ltd., will be introduced into service during the second stage of the construction of the works.

The Benfield plant has been designed to give an absorption efficiency of carbon dioxide and hydrogen sulphide of over 90 per cent and, in order to purify the gas to statutory requirements, it is passed through a further stage of purification before delivery into the grid main. The plant for the "Bischoff" system of oxide purification used for this final stage of hydrogen sulphide removal was supplied by Newton Chambers and Co., Ltd., and can be seen in our illustrations. In it the gas passes through two streams, each of four towers, designed for operation at a pressure of 340 lb per square inch. In view of the high working pressures involved the inlet and outlet mains of each of the two streams are provided with two valves for double isolation purposes and the space between the valves can be vented to atmosphere. Each purifier tower and one of two stacking towers is provided with



Lurgi house containing four gasifiers each designed to produce over 7,500,000 cubic feet of gas a day



Coal lock loading floor in gasifier house

twelve trays containing hydrated iron oxide. Essentially, the system operates on the principle that the oxide is removed in rotation from one tower to another at specific intervals and the towers themselves always remain in the fixed rotation order of 1, 2, 3, 4.

Normally both streams will be in action ; when it becomes necessary to renew the oxide of iron purifying material, one stream is completely shut off leaving the other stream temporarily to carry the full load. The towers in the stream which has been shut off are then opened ; the oxide trays in tower 1 are removed and placed in the empty stacking tower ; the trays in towers 2, 3 and 4 are moved back to towers 1, 2 and 3 ; and finally new trays containing a mixture of revivified and new oxide are placed in tower 4. The fouled oxide placed in the stacking tower is then removed for revivification. The oxide-changing operation on one stream can be carried out in one working day and the period between oxide-changing operations is expected to be about twenty-two days on maximum load. The changing operation will be " staggered," one stream being shut off every eleven days. A controlled oxygen supply is provided at the inlet to each stream for revivification *in situ* and the quantity of oxygen admitted for this purpose is determined by the concentration at the outlet of each stream.

Each of the towers of $1\frac{3}{16}$in welded mild steel plate is 46ft high by 6ft internal diameter and is fitted with a quick operating cover of mild steel. The two lines of four purifier and one stacking towers are enclosed within a brick structure for heat retention purposes with their covers projecting above the level of the flat roof. A 4-ton electrical overhead travelling crane running the length of the roof is used for lifting the tower covers and transferring the trays of iron oxide.

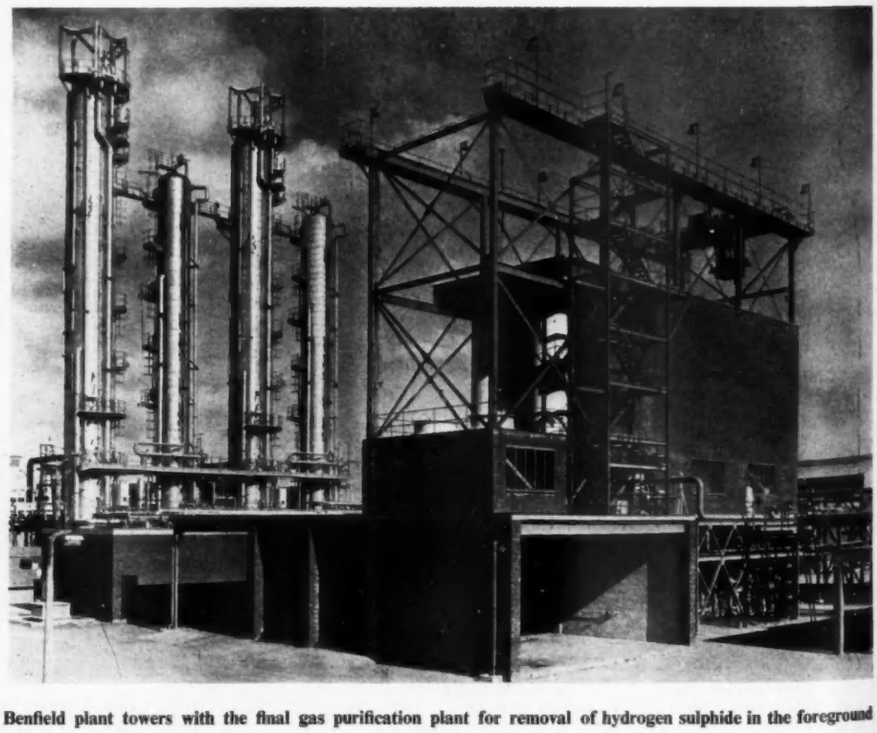
To ensure that the purified gas is dry for delivery at 250 lb per square inch into the high-pressure steel gas mains it is passed through a Denco Miller drying plant at the outlet of the " Bischoff " tower installation. At this final stage the gas has a calorific value of 400 B.Th.U. per cubic foot and before it is passed into the mains it is enriched to 450 B.Th.U. per cubic foot by the addition of butane. Butane for this purpose is supplied in liquid form by Scottish Oils and Shell Mex, Ltd., from the Grangemouth refinery, and is stored in three 56-ton capacity cylindrical tanks. Additional storage capacity will be provided for the butane by a spherical tank of 500 tons capacity now under construction. The butane is delivered to the site in road tank wagons from which it is transferred by pumps as a liquid under pressure to the storage tanks.

The Lurgi process calls for large quantities of high-pressure steam and oxygen and the two installations for these supplies are of interest. In planning the works it was decided that the grate to be installed in the steam raising plant must be capable of burning fuel containing a large percentage of fines and having a high ash content. To meet this requirement the Babcock and Wilcox " Bi-drum " boilers installed are equipped with " Ignafluid " stokers which operate on a " fluidised fuel bed " principle. Two of the three boilers have been installed, each having an hourly evaporative capacity of 45,000 lb of superheated steam at a pressure of 450 lb per square inch at a temperature of 730 deg. Fah.

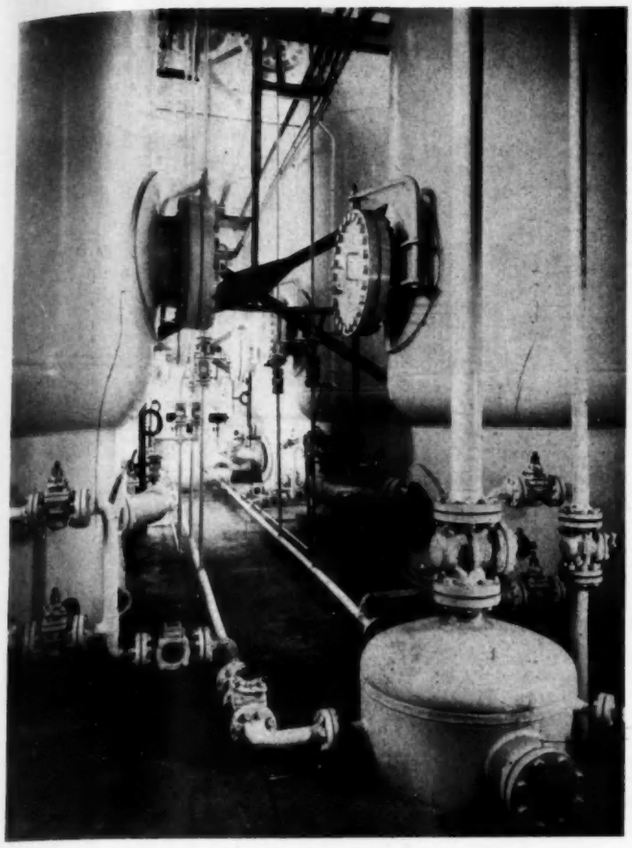
The coal, crushed to below $\frac{1}{4}$in, is delivered by a vibrating feeder into the boiler furnace through a port in the front wall. The coal cascades down on to a fuel bed that is maintained in a " fluidised " condition by pulsated air streams injected below a narrow chain grate. This grate, which is inclined upwards towards the rear of the furnace and which travels from front to rear at a relatively high speed, is regarded only as an ash carrier. Some of the fuel is burned in suspension, the remainder burning on the sloping sides of the fuel bed between the boiler side walls and the grate. The semi-molten ash flows by gravity down these sloping sides to the bottom of the fuel bed, and is conveyed by the chain grate as clinker to the rear of the furnace, where it is discharged to a suitable ash-removal plant.

Primary air from the forced-draught fan is fed to compartments below the upper strand of the grate, through divided trunking. The compartments are equipped with dampers providing for a decreasing air-pressure gradient from front to rear of the stoker. A motor-driven " pulsator," or rotary disc-valve, in the forced-draught fan outlet, serves to pulsate the primary-air flow through the grate to produce continuous " fluidisation " of the fuel bed, at variable frequency. This pulsation prevents segregation of the coarse and fine fuel particles and the agglomeration of clinker ; it also extends the working range by assisting combustion at reduced boiler loadings.

The primary and secondary air ducting is arranged so that proportions varying between 40 and 60 per cent can be supplied as primary and secondary air according to the quality of the fuel being burned. The secondary air is



Benfield plant towers with the final gas purification plant for removal of hydrogen sulphide in the foreground



Towers, gas mains and condensate drainage system inside final purification plant building

introduced mainly through a series of nozzles along the front and sides of the furnace, well above the sloping fuel-banks and the fluidised fuel-bed, and a small amount of secondary air is also passed under the rear arch on to the ash to ensure that combustion is complete.

This boiler plant has semi-automatic control, with manual control of the forced-draught and induced-draught fans, operating in conjunction with a system that depends on the pressure differential between the underside of the "fluidised" bed and the furnace above the bed. Variation from the predetermined differential initiates automatic adjustment of the fuel feed, so preserving the required balance between fuel feed and air flow. In all systems where combustion of the fuel takes place partly or wholly in suspension, there can be a problem of "carry-over" of fines. With the "Ignafluid" firing system, this "carry-over" is collected by grit collectors and refired into the furnace through nozzles adjacent to the fuel entry.

Westfield is the first gasworks in this country to use oxygen on a large scale for the production of gas and after inspecting a number of installations it was decided to install a plant of liquid-pump design made by the British Oxygen Company, Ltd.

The final decision to install a liquid-pump plant was reached because it provides the necessary facilities for adequate storage of liquid oxygen. This storage capacity is of importance in providing against unplanned shut-down which would have direct repercussions on output at this key gasworks. It is also necessary to have adequate storage to cover periods of major maintenance work; and the system adopted provides sufficient capacity to hold 560 tons of liquid oxygen in storage. The capital cost of equivalent orthodox-type gasholder storage would be over £1,000,000, whereas the method adopted cost about one-tenth that sum.

Each of the two "Tonnox" plants installed is designed to produce 100 tons per day of oxygen of 95 per cent purity at a pressure of 426 lb per square inch. Of this total 10 tons of oxygen a day can be available in liquid state for delivery to the storage tank, if required. The plants produce oxygen under pressure directly from an air separation unit by means of a liquid pump-heat exchanger system. The liquid oxygen fraction is continuously withdrawn from the system and compressed by a pump, whilst still in the liquid state, to a pressure of 426 lb per square inch. The liquid oxygen is vaporised in a heat exchanger and, after preheating, is delivered to the Lurgi gasifiers as gaseous oxygen at the required pressure of 426 lb per square inch.

In the second stage of the scheme there will be introduced into service a newly developed plant for the reduction of the carbon monoxide content of the gas to less than 8 per cent and, as already mentioned, a sulphur recovery plant for the removal of sulphur from waste gases. The carbon monoxide conversion plant installed at the outlet of the Lurgi waste-heat boiler will reduce the carbon monoxide content of the gas to less than 8 per cent and help to reduce the specific gravity of the final gas.

One of the problems that had to be solved at the plant was the daily disposal of more than 10,000,000 cubic feet of waste acid gases. These gases consist of 1½ to 2 per cent by volume of hydrogen sulphide and the remainder is mainly carbon dioxide. Catalytic oxidation of the hydrogen sulphide to sulphur dioxide before it mixes with the flue gases was selected as the most suitable process, and a contract for the design and construction of the waste gas disposal plant was placed with Simon-Carves, Ltd.

The acid gases from the regenerators of the Benfield plant are delivered to the disposal plant through a counter-current heat exchanger in which they are preheated by the effluent gases leaving the plant. The gases then pass to a line heater which uses fuel gas to raise the temperature of the acid gases to the optimum for conversion. Dilution air is added at the line heater to prevent the formation of sulphur trioxide by an excessive temperature rise across the oxidation kiln. After mixing with the combustion gases and the dilution air, the gases reach the oxidation kiln which incorporates a bauxite catalyst bed for converting the hydrogen sulphide to sulphur dioxide.

The plant is designed to deal with acid gases having a hydrogen sulphide content of up to 2½ per cent by volume at full load and automatic controls make sure that the correct quantities of fuel gas and dilution air are added. These controls also ensure that there is always an excess of oxygen in the kiln outlet gases. The entire plant is duplicated so that each section is capable of accepting the whole volume of the waste gases formed by operation of the first stage of the Westfield gasification plant. In this way, one section is always available for maintenance.

During the first stage of gas production at Westfield, a pilot-scale sulphur recovery plant is being built to prove the practicability of installing a full-scale plant to operate when the second stage of production is attained.

The design of the chimney stack used for discharging the treated acid gases, which are mixed with the boiler flue gases, is of interest. When considering the design of this chimney account had to be taken of the fact that the combined gases would have a specific gravity of 1·2 and an average temperature of 175 deg. to 260 deg. Cent. No thermal lift could be expected and it would be required to operate the chimney under slight pressure as it was stipulated that the discharge of the gases should be at a minimum rate of 50ft per second. An ingenious design of chimney put forward by the contractors, Teleman and Co., Ltd., was accepted. It comprises a "three-in-one" construction consisting of an outer reinforced concrete shell 275ft high with an external diameter reducing from 26ft 8in at the base to 21ft 9in at the top. Within this shell are three 5ft diameter flue shafts of 9in acid-resisting brickwork, each shaft being built up in 30ft increments between the floors of the concrete shell. From these floors access is available for the inspection and repair of the brick shafts, any one of which can be taken out of service whilst the other two are in operation. Large openings in the concrete shell provide adequate ventilation at all levels. By adopting this design there has been avoided the need for installing duplicate chimneys, as would otherwise have been necessary to ensure continuity of operation of the plant when repairs or maintenance work are required in the future.

The commissioning of Westfield was carried out in a very short space of time—coal was fed to the gasifiers on December 22, 1960, and gas was delivered into the grid five days later. We are informed that the reason that very few difficulties in commissioning were encountered and the ease in starting up resulted from the efficient design of the entire plant and the very careful attention which had been given to every detail of the programme of checking and testing all equipment before attempting to commission it. During the commissioning period Scottish Gas Board operators were trained by the commissioning team and by the engineers of the specialist sub-contractors. The fact that the plant was started up ahead of the contracted date and its service to Scotland began earlier than was thought likely, is a tribute to the highly successful co-ordination of all concerned in the project.

P. & O.-Orient Liner "Canberra"

No. II—(*concluded from page 980, June 16.*)

The turbo-electric liner "Canberra" has been built for the Australia–trans-Pacific service of the P. & O.-Orient lines and carries 548 first-class and 1690 tourist-class passengers and a crew of 960 at a service speed of 27·5 knots. The liner has a gross tonnage of 45,270 and a net tonnage of 23,968 and is propelled by twin screws, each driven by a double unit synchronous motor, power being supplied by two turbo-alternators. Normal service power developed is 68,000 s.h.p. and steam is supplied at 700 lb per square inch gauge and 950 deg. Fah. by three Foster Wheeler E.S.D. boilers.

IN our issue of last week we described the hull, accommodation, ship and auxiliary services, navigation and safety equipment of "Canberra" and this week we continue with details of the main and auxiliary machinery. Propulsion is by a twoshaft arrangement of turbo-electric machinery designed and manufactured by Associated Electrical Industries, Ltd. The plant, which was briefly described in THE ENGINEER of March 14, 1960, and more fully described in THE ENGINEER of November 18, 1960, has been designed to develop a normal shaft horsepower of 68,000 at 136·5 propeller r.p.m., to give the liner a speed in service of 27·5 knots, and a maximum continuous power of 85,000 s.h.p. The choice of this particular form of prime mover stemmed from an exhaustive consideration of proved techniques, new materials and manufacturing processes available, and final decisions were based upon the results of design studies carried out by the Yarrow Admiralty Research Department which co-operated with the technical staff of the shipowners. Turbo-electric drive was selected, in association with steam conditions of 750 lb per square inch gauge and 960 deg. Fah as being the form of propulsion best suited to meet operating conditions despite some penalty in the form of greater weight, more space and increased cost. The P. & O. in ships such as "Strathaird," "Strathnaver" and "Viceroy of India" has had considerable experience of turbo-electric drive, one of the advantages of which is that the propellers can run locked together in any required phase relationship as dictated by the need to keep vibration forces to a minimum. Furthermore, since the propellers are reversed electrically no astern turbines are required and full power is available for going astern.

The layout of the main and auxiliary machinery spaces can be seen in our line drawing included as a folding plate, which shows that starting from forward there is : a pump room ; air conditioning and refrigerating machinery space ; alternator room ; engine room ; propulsion motors ; and boiler-room arranged above the shafting. Between the alternator room and the air conditioning and refrigerating space is the aft stabiliser compartment while forward of the pump room is the forward pair of stabilisers. Continuing forward from this stabiliser compartment is a pipe passage, between the deep tanks, in which are located the service pipelines and also the lift which links the machinery spaces with the engineers' quarters in the superstructure.

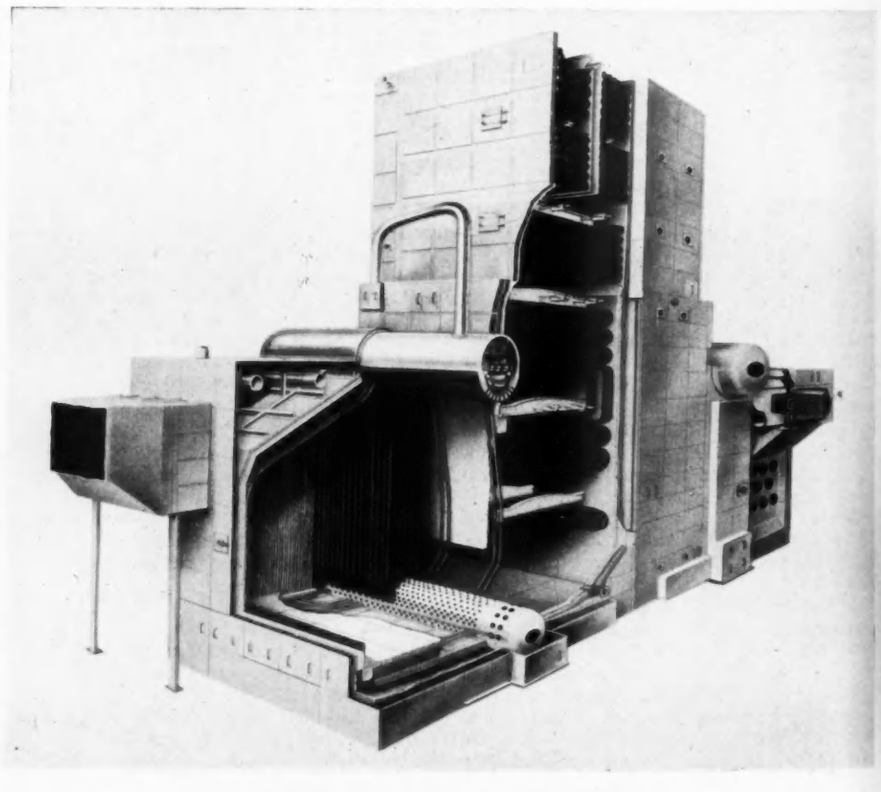
During trials the fuel consumption for the main machinery was under the guaranteed amount and was 0·48 lb per shaft horsepower per hour with the machinery developing 68,000 s.h.p. while the all-purpose figure was about 0·53 lb per shaft horsepower per hour. The maximum speed attained was nearly 29·3 knots at an overload power of 88,500 s.h.p. and during astern manoeuvring trials the ship was brought to a stop from 26 knots ahead in four minutes and twenty seconds.

PROPULSION MOTORS AND TURBO-ALTERNATORS

For powering the turbo-electric drive there are two propulsion turbo-alternator sets each independently supplying its associated propulsion motor. In addition, with one set shut down the other can supply both propulsion motors at powers up to 40,000 s.h.p. while port and starboard propellers can be synchronised by arranging the port alternator to supply the forward port and starboard motor units and the starboard alternator to supply the aft motor units. Each alternator set is rated at 32,200kVA c.m.r., 1·0 p.f., 6000V, two-pole, three-phase, 51·5 c/s, 3100A and 3087 r.p.m. which is equivalent to 85,000 s.h.p. on two shafts. Under normal service conditions the rating is 25,800kVA 5600V, 47·8 c/s, 2867 r.p.m. and equivalent to 68,000 s.h.p. With one set powering both motors at 40,000 s.h.p. the rating is 30,700kVA, 1·0 p.f., 4670V, three-phase, 40 c/s, 3800A and 2400 r.p.m. A high short circuit ratio of about 1·2 makes the alternator a stiffer machine and more able to cope with load swings. Fans on the alternator rotor circulate air in a closed system through sea water circulated air coolers.

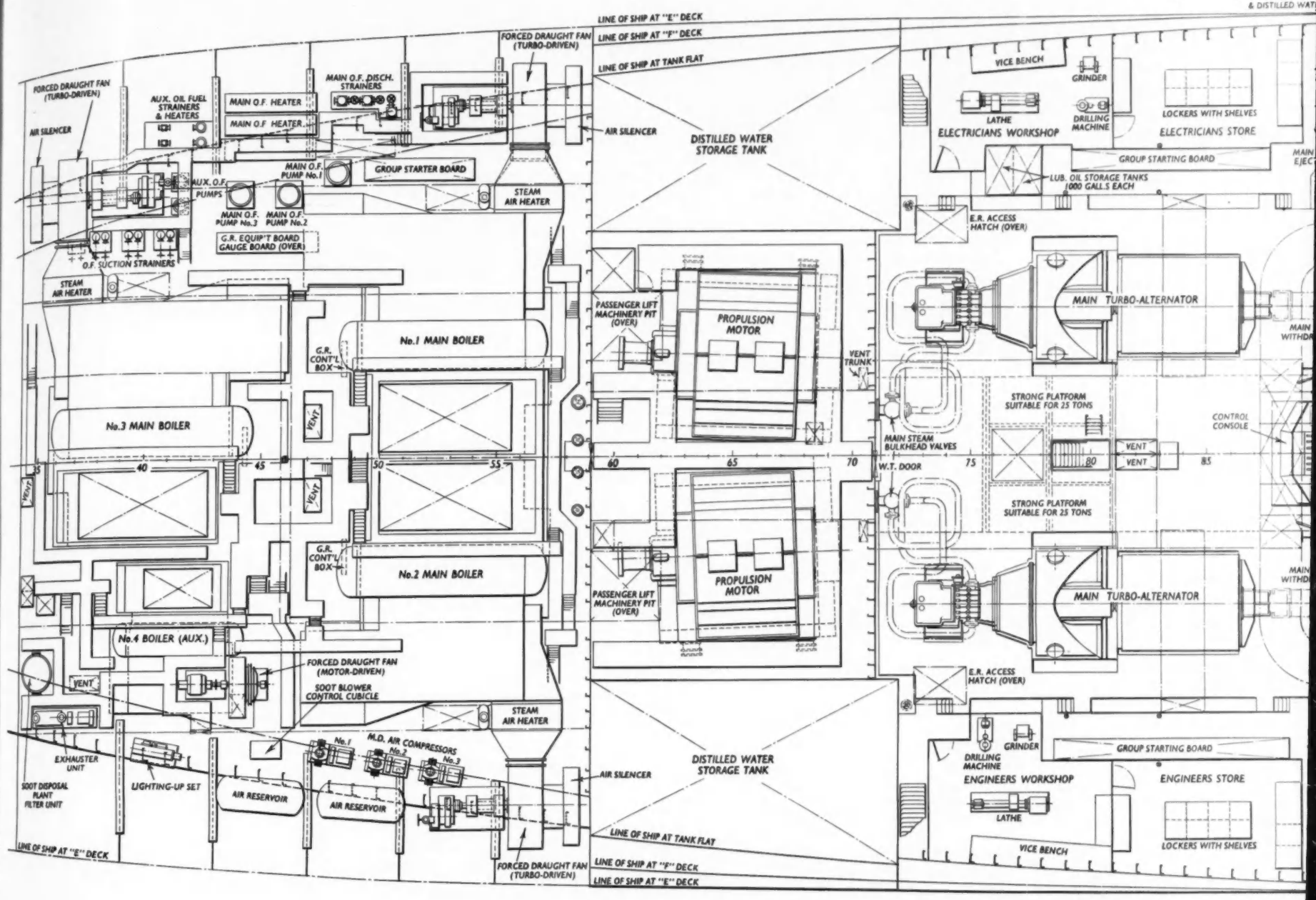
The turbine is a single-cylinder unit having seventeen stages of impulse blading, cam operated multi-valve control and twin-governors. The steam conditions are 700 lb per square inch gauge and 950 deg. Fah., and the condenser vacuum at service power is 28½in Hg with the sea water at 76 deg. Fah. The condensers, are of Weir "Regenerative" pattern, and each has a surface of 35,000 square feet and two scoops which are designed to supply enough circulating water to maintain the required vacuum without using the two Drysdale circulating pumps, each to which is rated at 16,700 gallons per minute. Vibration characteristics of individual turbine blades and the completed rotor have been calculated and the results incorporated in the design, and to ensure efficient operation supervisory equipment has been installed. This supplies a continuous record of mechanical behaviour and is of particular importance during starting-up and shutting-down when thermal differences are liable to cause difficulties to arise. Sensory heads measure differential expansions, detect any eccentricity, and vibration levels at a number of points on the turbine. Both turbine and alternator bearings are forced lubricated ; and the turbine and alternator are connected by a bellows pattern coupling.

The propulsion motors are of double unit design each consisting of two machines, electrically separate, built into one casing, and the ratio between the speed of the propulsion turbo-alternator and the propulsion motors is 21 to 1. They are synchronous machines having a salient pole rotor with squirrel-cage winding in the pole shoes for induction starting and reversing. Each forty-two pole motor has a maximum continuous rating of 42,500 s.h.p., 6000V, three-phase, 51·5 c/s at 147 r.p.m. and has a

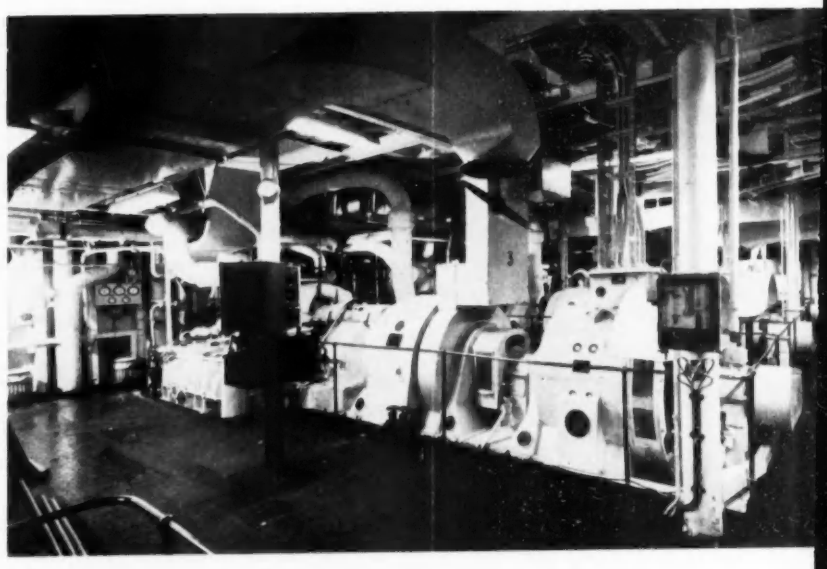


Cutaway view of one of the main boilers

TURBO-ELECTRIC AND AUXILIARY MACHINERY R

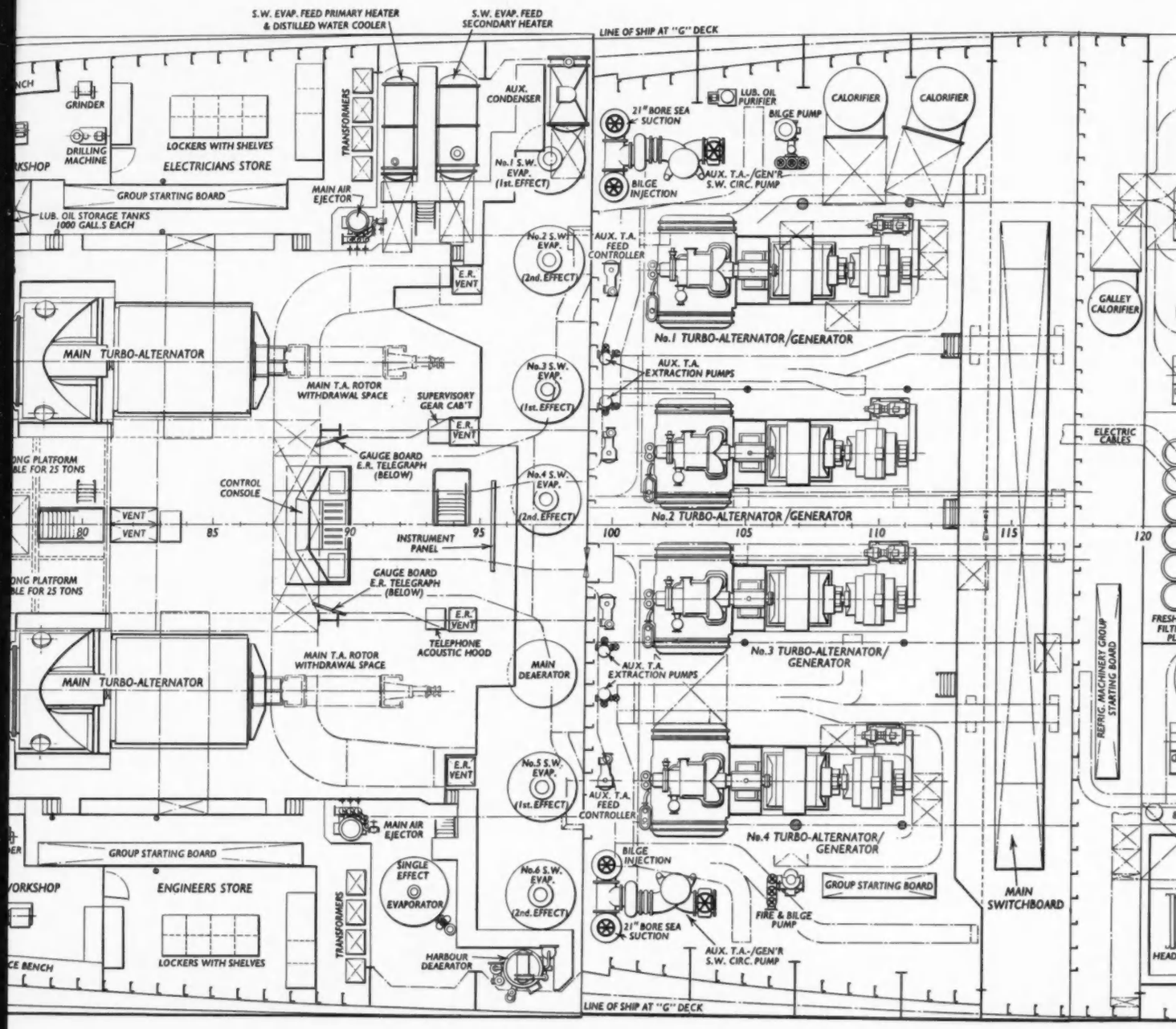


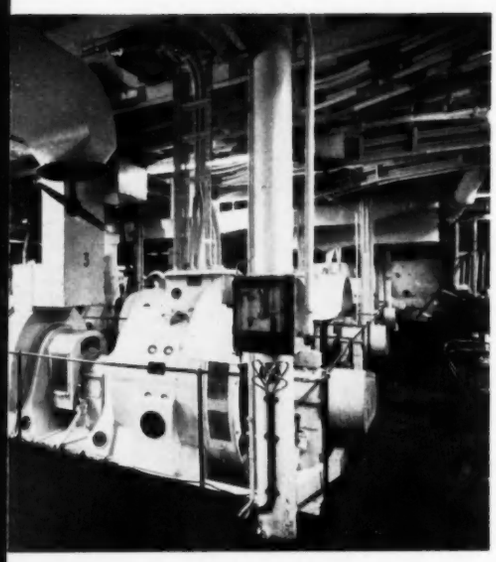
Main engine control console with one of two propulsion turbo-alternator sets in background



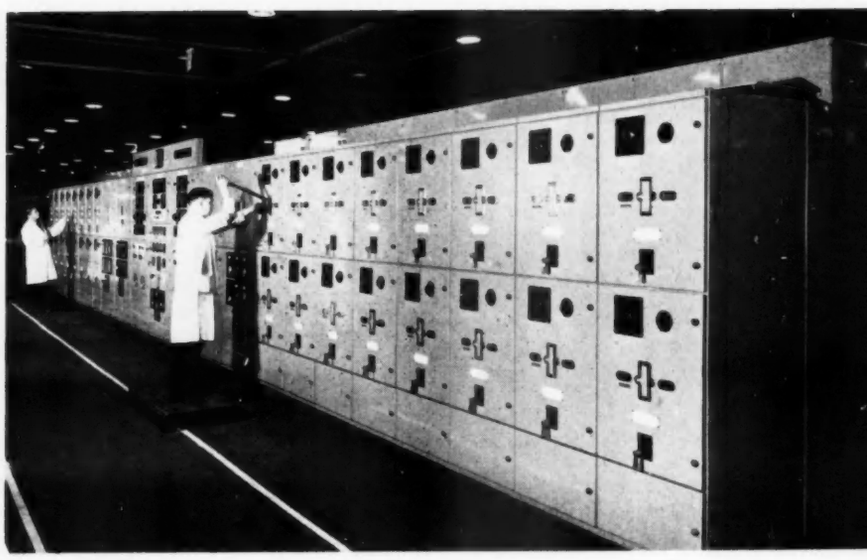
Auxiliary turbo-alternator room with four 1500kW 60 c/s a.c. generators, and 300kW d.c. excite

RY MACHINERY ROOMS OF P. & O.—ORIENT PASSENGER LINER



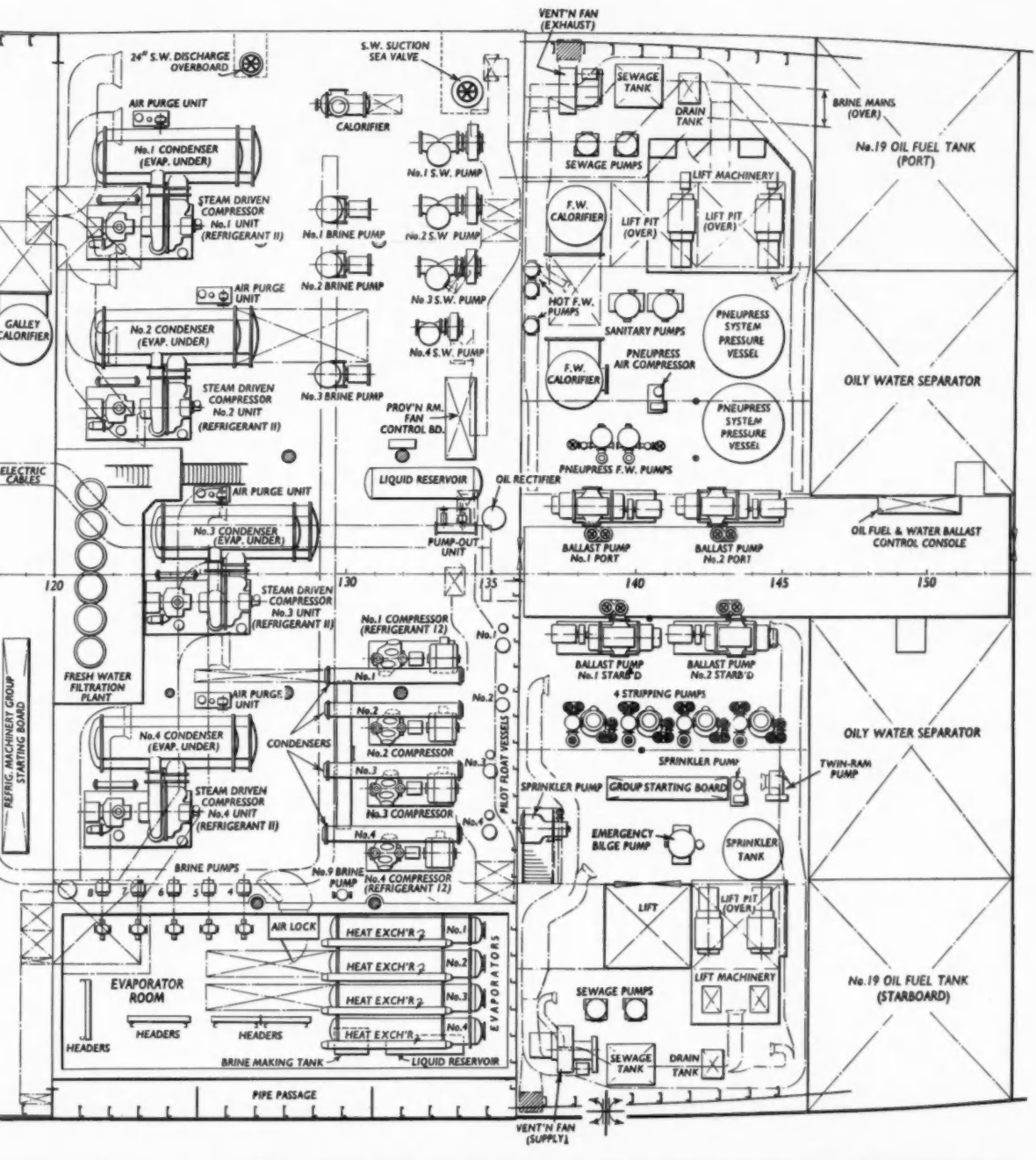


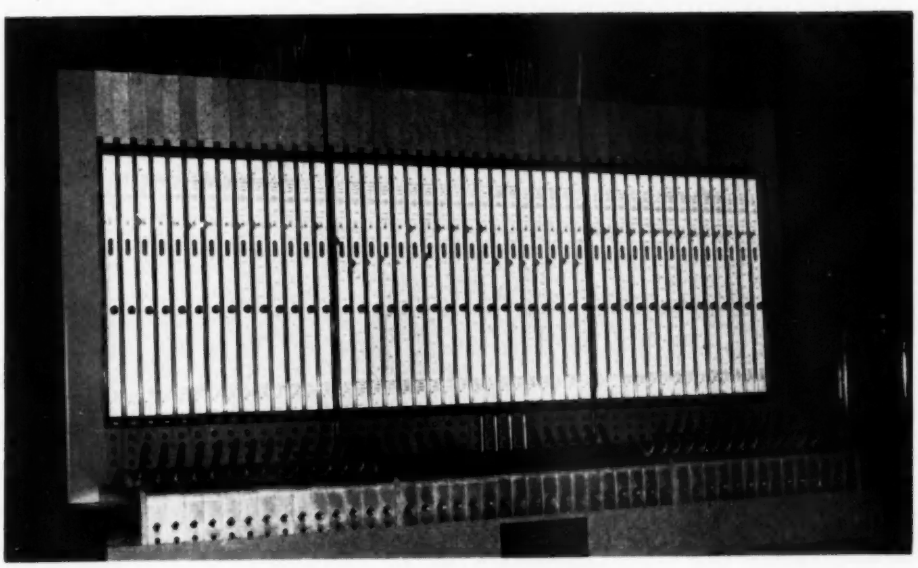
60 c/s a.c. generators, and 300kW d.c. exciters in tandem



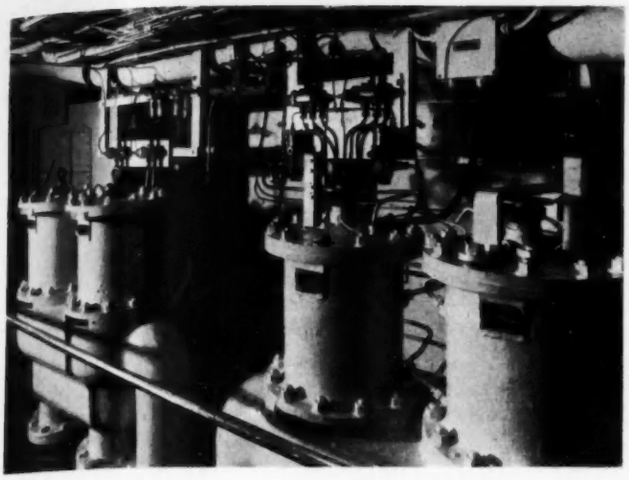
Main switchboard controlling the complete power supply to "Canberra"

INER "CANBERRA"





"Pilgrim" valve console controlling oil fuelling and ballasting



A pair of Pilgrim valves and air controls

closed air circuit incorporating fans and sea water circulated air coolers.

On the question of vibration all shafting modes have been investigated also propeller excited resonances of the "A" bracket shaft supports. Furthermore, with the turbo-electric drive the propellers can be given an optimum phase relationship so that the minimum vibratory force is generated. In the foreground of our illustration, in the folding plate, of the propulsion turbo-alternator room, is the control console in which "Cirscale" instruments give propulsion a.c. voltages and currents, shaft horsepower, exciter d.c. voltages and currents, the movement of each propeller and its revolutions per minute using Selsyn drives and the relative movement of the two propellers using a differential Selsyn. At each end of the console are short circuit relays in addition to the two sets of three propulsion levers, one set for each drive and each consists of direction, speed and starting levers.

Each propulsion motor drives a four-bladed propeller manufactured in "Nickalum" by the Manganese Bronze and Brass Company, Ltd., while spare propellers of "Heliston" design have been manufactured in high tensile "Novoston" material at the works of Bull's Metal and Marine, Ltd. Each propeller has a finished weight of about 29 tons. Open shafting, as used in naval practice, has been adopted instead of the more usual merchant ship closed bossing and the shaft runs in white metal bearings with "Simplex" oil seals at each end of the "A" brackets and hull bossing bearings. Intermediate steady brackets are fitted and equipped with "Tufnol" bearings and this material has also been used for the rudder bearings.

Boilers

To provide the necessary steam supplies for the propulsion turbo-alternators and the a.c. generators there are four Foster Wheeler E.S.D. boilers built under licence by the shipbuilders. Three of these units have a normal evaporation rate of 175,000 lb per hour, a maximum evaporation rate of 260,000 lb per hour and provide steam at 750 lb per square inch gauge and 960 deg. Fah. at the superheater outlet, the feed water supply being at 240 deg. Fah. The fourth boiler is an auxiliary unit having evaporation rates of 40,000 and 50,000 lb per hour respectively, the steam pressure and temperature at the superheater outlet being 750 lb per square inch gauge and 900 deg. Fah. The main boilers, of which we reproduce a schematic arrangement, have full air casings to suit operation with steam turbine-driven Howden forced draught fans, one per boiler, each rated at 88,000 cubic feet of air per minute against a pressure of 39in water gauge and fitted with a special air silencer at the inlet. Each turbine develops 657 h.p. at a fan speed of 1310 r.p.m. and with steam at boiler pressure. A motor-driven Howden fan of 17,000 cubic feet per minute capacity at 17in water gauge supplies the small boiler. A "Weldex" bled steam air heater and a Foster Wheeler gilled tube economiser are incorporated into each boiler. Two General Regulator all-electric control systems are fitted, one for the main boilers and one for the auxiliary boiler, and the control meters the supply of air and oil to each boiler to give maximum combustion efficiency over the operating range of the boiler. A fully compensated pressure regulating valve mechanically operated by the steam pressure regulator, controls the oil pressure to the burners. Combustion air supply to the main boilers is regulated by varying the speed of the F.D. fan in conjunction with controlling the movement of dampers in the air supply ducting. The final steam temperature is determined by the distribution of combustion air in the correct proportion between attemperator and by-pass duct, this being achieved by the automatic positioning of the attemperator shut-off and by-pass dampers by the temperature controller. There is also a manual-automatic control station for each temperature regulator.

Associated British Combustion, Ltd. supplied the oil burning installations, which include three of 29,500 lb per hour capacity for the main boilers and one of 5000 lb per hour rating for the auxiliary unit. These are of "Suspended Flame Duat" liquid fuel steam/mechanical pattern giving a wide turn down ratio and which can be arranged for pressure jet or steam assisted atomisation. An automatic system of sequence soot blowing has been provided by Clyde Blowers, Ltd., and for soot removal there has been installed a vacuum-cleaning system supplied by the British Vacuum Company, Ltd.

G. and J. Weir, Ltd. has been responsible for the main de-aerating closed feed system for the boilers and this includes: four 406,000 lb per hour main extraction pumps, two three-stage air ejectors, two gland steam condensers each of 250 square feet, one drain cooler extraction pump of 100,000 lb per hour capacity. Feed water is supplied by two three-stage turbine-driven pumps each having a capacity of 780,000 lb per hour. For harbour duties there are one turbine-driven four-stage pump and one electrically-driven eight-stage pump each of 50,000 lb per hour capacity. To ensure that the feed water is free of oxygen, de-aerating equipment is installed and consists of a 660,000 lb per hour main deaerator and two 808,000 lb per hour extraction pumps while for harbour duties there are two 72,000 lb per hour deaerator extractor pumps, two 105,000 lb per hour supply pumps and a deaerator of 50,000 lb per hour capacity. Also in the closed feed system are a four-pass condensate circulated distiller of 3000 square feet, and a salt water circulated distiller of 1300 square feet and rated at 400 tons per twenty-four hours. For make-up feed there is a vertical single effect evaporator having an area of 870 square feet and designed to produce 170 tons in twenty-four hours, one distilling condenser and one evaporator feed pump rated to discharge 1800 gallons per hour against a pressure of 45 lb per square inch. All make-up feed is passed through an "Ionostat" provided by The County Water Softener Company, Ltd, and rated to treat 170 tons per twenty-four hours, while immediate warning of impurity is given by equipment provided by Electronic Switchgear (London), Ltd. One additional source of make-up feed water is the collection of part of the condensed moisture from the coolers of the air conditioning plant and, depending on atmospheric conditions, amounts to 60 to 120 tons per day. It is treated in the ion-exchange plant, which strips out the CO_2, and stored in reserve tanks.

The Weir sea water distillation plant consists of six vertical double effect evaporators, each having a heating surface of 1050 square feet, and "Thermoflex" elements and vapour scrubbers, with a total output of 750 tons per twenty-four hours, together with a primary and a secondary feed heater. There are four 2100 gallons per hour brine pumps and two 14,000 gallons per hour feed pumps, all manufactured by Drysdale and Co., Ltd. This company has also supplied pumps for various services, including: two 240 tons per hour bilge pumps, four 230 gallons per minute, and two 60 gallons per minute lubricating oil pumps, two 3500 gallons per minute engine water service pumps, and two 108/90 tons per hour pumps for the "Pneu-press" system. Also on board are two 80 tons per hour Allen self priming bilge pumps, one 240/120 tons per hour at 150ft head, Allen vertical single-stage emergency bilge pump, and two sanitary pumps able to deliver 240 tons per hour against a head of 170ft. This company has also manufactured the electrical driving motors for a number of other pumps. In the engine-room there is a Worthington-Simpson single-stage 400 tons per hour fire and bilge pump, and also a centrifugal 350 tons per hour pump, and in the generator room a 200/80 tons per hour two-stage fire and bilge pump. Other auxiliaries in the machinery spaces include: air compressor, for the "Pneu-press" system, rated to deliver 100 cubic feet of air per minute at 120 lb to 150 lb per square inch, two Mather and Platt pumps, for the sprinkler system, one motor driven of 560 gallons per minute, and one diesel-driven of 625 gallons per minute, together with two Holden and Brooke twin ram pumps of 120 gallons per hour at 150 lb per square inch capacity. For the lubricating oil there are four 230 gallons per minute Serck coolers and Auto-Klean strainers, two 300 gallons per hour "Titan" purifiers and two 100 gallons per minute Mirrlees emergency supply pumps.

It is noteworthy that bolted flanges have been, with few exceptions, virtually eliminated from the main steam pipe system while maintaining adequate provision for survey, inspection and testing requirements. Special

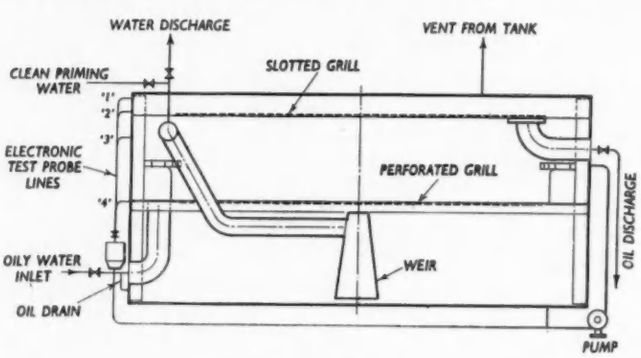
welding techniques, using the root insert method, largely based on experience in thermal and nuclear power stations have been developed for the purpose with the co-operation of the Ministry and Lloyd's Register. Aiton and Co., Ltd., carried out a full stress analysis of the main steam, auxiliary steam and feed systems and fabricated the 10in bore by 0·913in thick main steam leads in cold drawn 1 per cent chromium, 0·5 per cent molybdenum alloy steel, the 6½in bore by ⅝in thick leads to the propulsion turbo-alternator sets and the 8in bore by 0·76in thick feed system operating at 1150 lb per square inch gauge and 240 deg. Fah.

Electrical Plant

The Heavy Plant Division of Associated Electrical Industries, Ltd., has also manufactured the auxiliary turbo-alternator sets for meeting the demand for electrical power for engine-room auxiliaries, heating, lighting, refrigeration plant, hotel and domestic services. For this purpose there have been installed four 1500kW, 440V, three-phase, 60 c/s, 6000–1200 r.p.m. geared pass-out turbo-alternators. A view of the turbo-alternator room is included on our folding plate. Steam conditions at the turbine inlet are 700 lb per square inch gauge and 930 deg. Fah., and the pass out pressure 70 lb per square inch gauge, the quantity being 15,000lb per hour. Tandem driven from each alternator is a 300kW, 300V, 1000A, d.c., continuously rated, 1200 r.p.m. propulsion main exciter and a vee belt-driven 1800 r.p.m. exciter set including the pilot exciter for the propulsion main exciter and the auxiliary alternator. Forming part of the equipment are two 9150 gallons per minute Worthington-Simpson salt water circulating pumps, four Weir feed controllers and four 20,418 lb per hour extraction pumps, also four 3620 gallons per hour Serck lubricating oil coolers and one 100 gallon per hour "Titan" purifier.

For emergency purposes there are mounted on "C" deck, forward of No. 1 Hatch, two 200kW G.E.C. three-phase 60 c/s alternators each driven at 1800 r.p.m. by a Paxman twelve-cylinder air-cooled "Vega" diesel engine. This engine is normally rated at 400 b.h.p. at 1800 r.p.m., but for this application is rated at 291 b.h.p., corresponding to the electrical output. The main switchboard, which we illustrate on our folding ing plate, and was supplied by The English Electric Company, Ltd., is mounted athwartships at the forward end of the generator room. The board is an outstanding example of the growing use of a.c. on board ships and consists of high breaking capacity 440V air circuit-breakers. There are thirty-eight circuits, and the switchboard, measuring 71ft 6in in length, is arranged with circuit breakers in double tier formation and includes: four 3000A circuit-breaker incomers from the 1500kW alternators; four alternator excitation control panels; one synchronising control panel; and twenty-eight circuit-breakers controlling outgoing loads up to 1600A. In addition to protective and metering devices there is a tripping system which isolates certain non-essential services in the event of sustained overload. The same company also provided forty-eight transformers covering a range from 20 to 75kVA. Emergency electrical supplies are provided by a Nife 230V nickel-cadmium alkaline battery capable of supplying a load of 814A during a period of thirty minutes.

Ventilation of the machinery spaces is effected by fans manufactured by Woods of Colchester, Ltd. Air is supplied to the boiler room by four 48in single-stage units of 35,000 cubic feet per minute capacity at 1½in water gauge, and exhausted by four fans of similar diameter but rated at 45,000 cubic feet per minute at 2½in water gauge. Two similar units exhaust the engine-room while six fans of the same capacity but at 1½in water gauge provide the air supply. Ventilation of the shaft tunnel is by one fan of 10,000 cubic feet per minute at 1½in water gauge while one of 2000 cubic feet per minute at the same pressure ventilates the engineer's store. Air supplies to the generator room are provided by two 35,000 cubic feet per minute at 2½in water gauge fans and are exhausted by two fans of the same capacity but at 1½in water gauge.



Diagrammatic arrangement of oily water separator tanks

Mention has been made already of the air-conditioning and refrigeration machinery which includes four two-stage centrifugal compressors. These are driven at 5150 r.p.m. by a single-stage turbine having a two-row wheel and taking steam at 700 lb per square inch gauge and 900 deg. Fah. The turbine back pressure is 25 lb per square inch gauge.

A higher service speed, shorter stays in ports, and a consumption of fuel amounting to about 450 tons per day in association with matching ballasting arrangements necessary to meet damaged stability requirements has had considerable effect upon the design of the system installed. Older methods had to be scrapped and new thinking applied to this control of ballast and oil fuel valves and the problem was a composite one involving the rapid taking on board of several thousand tons of oil and the processing of oily ballast water. These requirements resulted in the development of the "Pilgrim" valve, manufactured by James Gordon Valves, Ltd., which is of mushroom design but without restricting mitred skirts and is pressure balanced. A pneumatic cylinder operates the valve head and the valve automatically fails safe and firmly closes should the air supply fail.

In addition to the closed and open positions the operating air can be admitted so that the valve travel is limited and provides a "cracked" position of the valve which is necessary when engaged in tank topping up operations. The valves are in pairs, one for water ballast and one for oil fuel, and they number ninety-two with, in addition, some thirty-two stripping valves. Actuation is by Schrader air controls which are grouped in a console built by Wheatley and Dyer, seen in our illustration on the folding plate, and consist of Schrader Midget Disc Valves from which control air is passed to valves located up to 210ft away. At the console there is a control arm working in a quadrant for each tank and movement of 45 deg. in one direction actuates the main ballast valve via pilot valves through the "shut" "cracked" and "open" positions. Movement in the opposite direction operates the corresponding fuel valve. The actual valve openings are indicated by red, amber and green lights through the medium of micro-switches. Since there may be the possibility of confusion when a number of signals are displayed and rapid action is called for a 95 per cent full indicator light is incorporated in the top of the control arm. The flashing of this light warns the operator to move the control to "cracked" position. A special key can interlock the control arm so that it can only be moved over half the quadrant at a time. Double bottom tanks are fitted with a "stripping" connection and each control unit also has a "stripping" lever to operate the "Pilgrim" stripping valve. Forming part of the control console are Malone tank depth gauges which have a movable cursor fitted at a point corresponding to 95 per cent full, the position of cursor being adjusted by a vernier screw to allow for variation in the gravity of the contents of the tank. Our illustration shows a pair of "Pilgrim" valves and associated air controls.

For handling the ballast there are four 250 tons per hour Stothert and Pitt horizontal screw pumps and the same firm has supplied four stripping pumps rated to handle 75 tons per hour of oil fuel or 70 tons per hour of waste ballast. Built into the ship's structure are two specially designed Victor oily water separating tanks each of 750 tons per hour capacity. These are of the gravity flow principle and are automatic in operation and incorporate electronic insulated multi-probe dual level controllers which, by permutation of numbers of probes, regulate the discharge of oil or water and maintain the oil/water interface between fixed limits, taking into account the effects of roll. An over-ride alarm probe stops the flow of oily ballast to the tanks should the oil build down to an excessively low level. As can be seen in our diagrammatic arrangement of the system there is a perforated grill at half height and a slotted grill at a higher level. Contaminated ballast is pumped into this compartment, the oil rising through the slotted grill to discharge and the water sinking through the perforated grill into the lower chamber from which it is withdrawn under a weir. One of the tanks treats large quantities of lightly contaminated ballast water and when the level in the ship tank is low the ballast pump is shut off and the stripping pump started and forwards the heavily contaminated ballast at a low rate to the second of the separator tanks. An anti-sludge additive "Duramiss" is added to the fuel and another chemical used to deal with fuel is "Fomescol" which is a surface active agent designed to break down water-in-oil emulsion collected from oily-water separators. In "Canberra" the oil from the separators is treated with "Fomescol" which strips out the small amount of salt water still contained in the fuel so that the dry oil is recovered and used as fuel.

Electrical Manufacture in Britain's Economy

In one of the papers presented on June 14 at the British Electrical Power Convention at Eastbourne, Mr. Stanley F. Steward, director of BEAMA, discussed the key position of the electrical manufacturing industry in the national economy, and offered a forecast of the pace and pattern of the growth of the industry in the future. He showed how the industry's history is linked with that of its trade association, BEAMA, which this year celebrates its Golden Jubilee. Finally he outlined the role of BEAMA in fostering co-operation and helping industry to master the complex and competitive trading conditions that face it. Extracts from the second part of Mr. Steward's paper are reproduced below.

A CHARACTERISTIC feature of the electrical industry has been its remarkable rate of growth so that its volume of output during the post-war period has increased faster than any other major industry. Taking the Board of Trade index of production for 1948 as 100, then the 1960 figure for electrical manufacturing is 229, for vehicles 226, for chemicals 213, and for all manufacturing 159.

Over the same period, when electrical production has more than doubled, employment in the industry increased by about 40 per cent, indicating a strong rising trend in productivity, and a factor of vital importance.

The changing pattern of the industry is indicated by the following table which classifies output by the major sectors from data taken from the Census of Production for the years 1948 and 1958.

	Percentage of total output	
	1948	1958
Electrical machinery	54	25
Allied plant and equipment ...		24
Electronics and telecommunications equipment	20	30
Electric wires and cables	19	11
Domestic electrical appliances...	7	10

Two sectors of the industry have shown outstanding growth over the last decade. These are domestic electrical appliances and the electronics and telecommunications groups of equipment. Output here quadrupled between 1948 and 1958, appliances now representing 10 per cent of the total output of the industry and electronics and telecommunications equipment, 30 per cent.

Since 1958 trading conditions in the domestic appliance and the radio and television sectors have been undermined by frequent Government policy changes on credit control, culminating in a serious check to growth in 1960. It will need a stable hire-purchase policy and a more modest rate of deposit for these appliances to enable the long term trend to reassert itself.

Employment.—In October, 1960, employment in the industry reached the highest-ever peak of 795,800 workers, 28 per cent of whom were engaged in the electrical machinery sector and 38 per cent on electronics and telecommunications equipment.

Electrical manufacture is the largest industrial employer of both scientists and technicians and the Industry's increasing need of design and research staff is likely to make heavy demands on the available trained personnel. In 1959 the electrical manufacturing industry employed 13,380 qualified scientists and engineers, representing about 21 per cent of the total in the whole of the manufacturing industries of the country. Also in a recent survey by the Ministry of Labour it was shown that the proportion of technicians working in the industry was 11·6 per cent of the total, higher than in any other industry. Because of the growing demands of electronic and nuclear developments, it is certain that over the next few years the need for qualified scientists and engineers will increase substantially and one of the factors which will determine the pace of the industry's expansion is the extent to which the universities and technical training institutions can provide them.

Capital Investment.—By its very nature as an expanding and technically progressive industry, electrical manufacture makes large demands for capital investment, and another factor on which the success of the industry depends is its ability to continue the present substantial rate of capital investment. Making allowance for ancillary activities (e.g. separate research laboratories) it is probable that a total investment of £400 million has been made over the ten years 1950-59 and two-thirds of this during the last five years.

The three-fold increase in the annual level of the electrical manufacturing industry's capital investment between 1950 and 1959 is significant. This is a higher rate of increase than other manufacturing industries, although of course the total capital requirements of different industries vary considerably. The following table shows the comparison.

Capital Expenditure by U.K. Manufacturing Industries (Establishment Basis)

	1950	1959	Increase
	£m	£m	Per cent
All manufacturing	444	820	+ 85
Electrical engineering...	15	48	+220
Vehicles and aircraft...	33	58	+ 76
Metal manufacture	58	134	+131
Engineering (other than electrical) shipbuilding and other metal goods	65	142	+118
Chemicals and allied industries...	89	154	+ 73
Textiles and clothing	64	67	+ 5
Paper and printing	24	52	+117

Source : Census of Production.

Although full figures are not available, it is clear from the published reports of the chief electrical manufacturing companies that earnings over this period have not risen to anything like the extent of the capital needed to generate them. As a consequence the return on the capital employed is lower than in many industries. This is because of the necessity for large capital investment to maintain a technical lead and also because highly competitive trading conditions have put profit margins under severe pressure. If the electrical industry is to be able to continue the rate of capital investment necessary to maintain its leading position, the large investment in equipment and research over recent years must now produce its full measure of profitable business. The financial status of this industry is of great importance and a period of excessive price warfare, with inadequate margins, could deter investment and produce a dangerous situation from the national point of view.

Research and Development.—The same reasons which have compelled the industry to undertake substantial capital investment to maintain its position against world competition have placed great emphasis on research. It is noteworthy that between 1955 and 1958 the electrical manufacturing industry's annual expenditure on research almost doubled, rising from £33,000,000 to £65,000,000. In addition much valuable work is done in co-operation with the research associations, the universities, and with the research organisations of public bodies, such as the Electricity Council, the Central Electricity Generating Board and the Atomic Energy Authority. Taking all these activities into account, it seems probable that the electrical industry as a whole is spending £80,000,000–£90,000,000 per annum on research.

The full fruits of this investment in research by the manufacturers will be gathered in the future, but already increases in the efficiency and size of generating sets have been made possible through the research and development programmes of the electrical industry. There is every prospect that striking progress in the design of conventional generating sets will continue with great benefit to the country through the reduction in the cost of generating electricity.

It will be seen from this picture of the structure of the electrical manufacturing industry that is is expanding rapidly and that its success is dependent on the continuance of a large capital investment programme and a substantial expenditure on research. These factors have given a strong impetus to the trend, particularly in the heavy plant and highly technical sectors, towards groupings of firms through amalgamations or consortia and, perhaps unintentionally, the monopolies legislation has increased this tendency. The three largest companies now employ nearly one-third of the total manpower of the industry. Such developments bring problems of organisation and management on account of size, but it should improve our ability to meet world competition in those fields where large-scale production and continuous technical advances are vital.

Electrical Exports

Last year's total of electrical and allied engineering exports reached £293·4 millions, about 3½ per cent more than the previous year and a new record for the industry. But there is no complacency in the industry and the electrical manufacturers are conscious that a much greater increase will be necessary if they are to hold their own in the world scene. For several years now, U.K. electrical exports, whilst steadily increasing, have secured a declining share of the expanding world market. For instance, West Germany's 1959 exports were up by 15 per cent on the previous year, whilst Japan, although smaller in comparison, increased hers from £35,000,000 to £71,000,000.

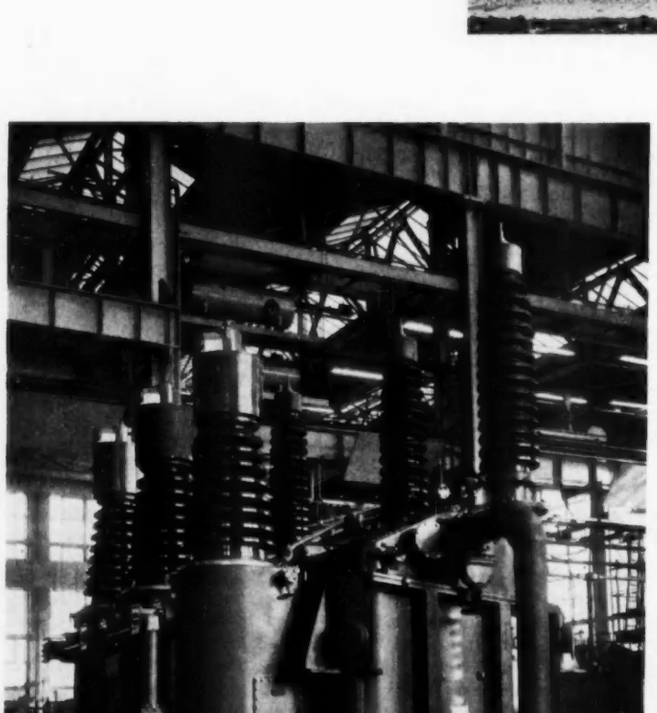
The importance of the Commonwealth is clear, the five major Commonwealth countries accounting for over one-third of the industry's total sales overseas. Large markets have also been developed in other parts of the Commonwealth, notably West Africa, where sales to Ghana and Nigeria totalled £11,000,000 in 1960 and to Rhodesia and Nyasaland, where exports were close on £9,000,000 last year. Generally speaking, however, in recent years the proportion of total electrical exports to the Commonwealth

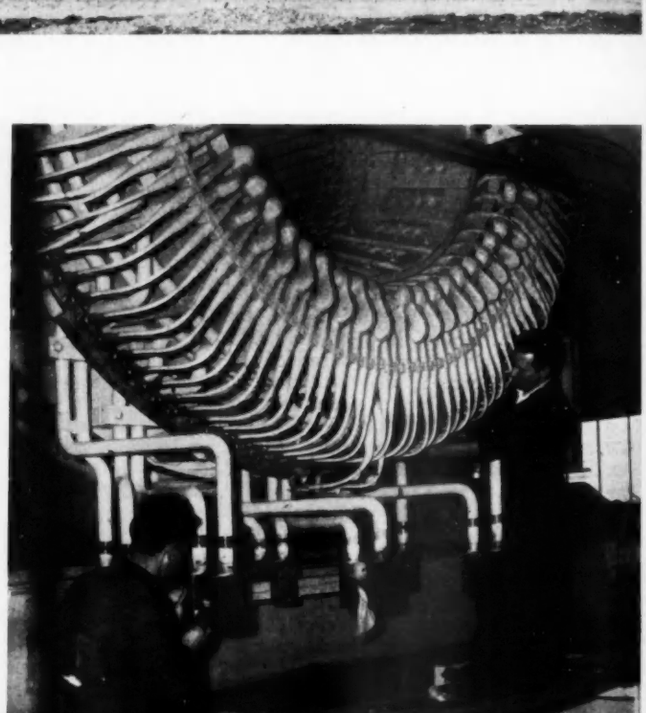
British Electrical Plant

Some typical examples of modern heavy electrical plant made in Great Britain are illustrated here. The picture, RIGHT, gives a general view of the Central Electricity Generating Board's 275kV Supergrid switching station at Feckenham, Worcestershire. It provides an interesting example of the C.E.G.B.'s efforts to standardise designs with the co-operation of the manufacturers. For the isolator, which can be seen in the centre of the photograph, was designed jointly by A.E.I., English Electric and the G.E.C. and was made at the Stafford works of the second named. This equipment is a 2000A isolator and earthing switch designed for a throughput of 15,000MVA at 275kV. On the left of the picture is one of the 7500MVA English Electric air-blast circuit breakers. The same company has in hand an order to extend the switching station with new circuit breakers rated at 15,000MVA.

BELOW, LEFT, we show a 135MVA, 275kV/132kV, three-phase, 50 c/s Ferranti transformer being tested at the company's works in Hollinwood, Lancs, before being shipped to South Africa where it will be installed in the Nevis distribution station of the Electricity Supply Commission of South Africa. This transformer is equipped with fully insulated line-end tap-changing equipment.

BELOW, RIGHT, is a close-up view of part of the stator winding of a 200MW, A.E.I. turbo-generator being erected at the C.E.G.B.'s Willington "B" power station, near Derby. The end connections of the water-cooled stator winding can be seen.





has tended to fall slightly—from 61 per cent in 1958 to 60 per cent in 1959 and to 57 per cent in 1960.

The reason can be seen in the industrial developments and rising standards of living in Western Europe, a market to which the electrical industry is paying increasing attention. Exports of a value of £70,000,000 were made to Europe last year : £34,000,000 to Common Market countries (an increase of 25 per cent) and £21,000,000 million to E.F.T.A. countries (an increase of 16 per cent). A rapid trade expansion is developing between the industralised countries of Western Europe and it is interesting to note in passing that Western Germany is our best single market for domestic washing machines, whilst on the other hand, it provides one-fifth of our total electrical imports. Because of their potential importance as an export market for electrical products the BEAMA commissioned a special study of the future requirements of the Common Market countries, and this has brought out the tremendous opportunities for British electrical exports to Europe over the next five years.

Unfortunately, an expanding industry seems to invite frequent Government reviews and policy fluctuations. During 1960 the electrical industry had to withstand a succession of blows. The nuclear programme was halved, railway electrification was held up and credit control changes played havoc with home and export markets for domestic appliances. The time has come to recognise that electrical manufacture is a growth industry of vital importance in the national economy and that its success can be seriously jeopardised by vacillations in the Government's capital investment and credit control policies.

It has become axiomatic that in Britain the demand for electricity doubles every ten years and there seems little doubt that the annual consumption will be more than 210,000 million units by 1970 which, even if a system load factor of 50 per cent could be achieved, could produce a maximum demand of 48,000MW. The effect of this rate of increase will permeate all sectors on the manufacturing side, although not uniformly in each sector. Viewing the industry as a whole, however, experience suggests that the overall rate of future expansion in electrical manufacture will continue the trend established during the post-war period. During the past ten years, the volume of output has increased by 83 per cent and an increase of this order during the next ten years would give a total output of £2900 million at present values by 1970. As was pointed out earlier, domestic appliances and electronic equipment have been the fastest growing sectors of the industry, and this pattern seems likely to continue during the next decade. In this context it is worth mentioning that an important and stabilising feature of the industry, is the fact that the largest firms participate in the domestic and electronic sectors as well as in the heavy plant sector.

For the purpose of this paper it will be sufficient to look in a preliminary way at two distinct sectors, power plant and domestic appliances, both of which are closely bound up with national policy and the economic growth of the country.

The Power Plant Programme.—The present plans for increasing the installed capacity of Britain's electricity supply system envisaged the commissioning of 2000MW to 2500MW of new generating plant each year. In England and Wales, the C.E.G.B. is planning to have available at the end of 1964, a total net output capacity of 34,800MW*, and has suggested that a peak maximum demand of 31,000MW may be expected in weather conditions of average cold spell in the winter of 1964-65. The peak demand experienced on December 13, 1960 was 24,445MW.

The forecasting procedures of the electricity supply industry are thorough and well informed but it would seem that this programme was drawn up on the assumption that there would be some decline in the 6·9 per cent average rate of increase which has occurred in recent years. I believe there are now grounds for thinking that a programme on this basis leaves too narrow a margin of capacity under severe weather conditions. Support for this view came towards the end of last year when for a period of five or six weeks the rise in demand approached 16 per cent and aroused concern about continuity of supply under extreme weather conditions, bringing the rate of increase for the whole year to 14 per cent. Mild weather and a record installation of plant helped to save the situation but it is evident that the programme needs a careful reappraisal by the authorities if this difficulty is to be avoided in the future.

This reappraisal will have to take into account the findings of any investigation into the nature of the unexpected upsurge and the extent to which it is likely to be repeated in the future. Some pointers occur in the statistics of sales of domestic appliances and in the growing recognition of the economy and convenience of electricity when properly applied to space heating. It may well be found that a new trend is emerging in the continued change to electricity as a source of power. When regard is paid to the pressure on industry to increase productivity, the growing adoption of automation, the clean air legislation, and the necessity to eliminate domestic labour, it is difficult to resist the view that the rate of growth of demand will be greater in the next decade than in the last. Furthermore, it is apparent that the pace of Britain's industrial growth must increase if we are not to fall behind our overseas competitors. This will inevitably add further to the demand for electric power.

Nothing could be more damaging to the cause of electrical development than any uncertainty about the continuity of supply. Bearing in mind the amount of old plant in service, the manufacturing capacity available and the likely trend of demand it would seem to be shortsighted to run any risk of under-providing for generating plant requirements in Britain during the next decade.

The power plant situation is complicated both for the manufacturers and the supply industry by the rapid advances and fundamental developments which have occurred in the last few years in the size and specification of generating plant.

A significant indication of the future pattern has been given by the announcement of the contracts for the 2000MW stations at West Burton and elsewhere each comprising four 500MW single shaft sets. A few years ago this capacity would have been provided through a number of separate contracts which would in the normal course of competition have been spread over the plant industry. In capacity terms, orders are bigger but the increase in size of individual sets and the concentration of such large capacity in a single station limits the number of separate contracts and the frequency with which each firm can hope to participate.

The problem for the plant manufacturers is further complicated by the fluctuations in the Government's policy on nuclear plant and the fact that the high cost of research and development in the nuclear field can only be justified by the prospect of substantial and remunerative business in the long run.

The C.E.G.B. has a task of extraordinary difficulty in balancing the advantages of nuclear achievements and conventional plant improvements and it seems clear that the latest supercritical sets operating near to base load conditions will produce results which will call for considerable advances in nuclear power techniques before the break-even point is reached.

In a way, these problems are peculiar to the British electrical manufacturing industry as our main foreign competitors are not faced to the same extent with the nuclear complication nor with the disadvantage of the long interval between major contracts with individual firms. There is therefore a vital national interest here as, whilst an overriding consideration must be the maximum efficiency and economy in the operation of the national generating system, our ability to compete successfully abroad in this all important field depends on a full and efficient use of our productive capacity. The working relationships and co-operation between the supply industry and the plant manufacturers are excellent at all levels and with so much in common and such a vital national interest at stake, it should be possible to formulate programmes and work out contract procedures which will ensure that the best use is made of the resources available, to the advantage of the public interest in every way.

Market for Domestic Electrical Appliances.—For the domestic appliance manufacturers the future offers great opportunities. All the evidence leads to the conclusion that there will be a steady growth in demand throughout the next decade.

As will be seen from the following table many appliances have considerable development ahead if we are to approach American levels of ownership.

Estimated Percentages of Households Owning Domestic Appliances

	U.K.	U.S.A.*	W. Germany
	Per cent	Per cent	Per cent
Electric blankets	23	24	n.a.
Electric cookers	30	36	36
Irons	85	89	93
Food and drink mixers	4	56	12
Refrigerators	25	98	32
Shavers	28	73	36
Toasters	10	80	n.a.
Vacuum cleaners	73	74	58
Water heaters	40	19	11
Washing machines	40	95	29

*Reproduced by permission of *Electrical Merchandising Week*, a McGraw-Hill publication.

Electric space heating despite the competition of alternative fuels seems certain to increase more rapidly. It is becoming widely realised that for short period heating it is unrivalled for cost, convenience and cleanliness and that by intelligent use of thermostat and time switch a great deal of domestic space heating requirements can be met by the controlled short period use of electricity. In addition, modern developments of floor heating and off-peak storage heaters are bringing the complete electric heating of commercial and domestic premises right into the realm of practical and economic advantage. In fact, the whole modern conception of electric space heating deserves a special and thorough study by the industry so that both supply and manufacturing sides are ready to cater for the inevitable growth in demand.

Allowing for present ownership levels, an attempt has been made to estimate the annual rates of deliveries to the home

* C.E.G.B. Annual Report, 1959-60.

market by the middle of the sixties. The following table indicates a probable pattern of demand.

Estimates of U.K. Home Deliveries of Selected Domestic Electrical Appliances in 1965 *compared with* 1959

	1965 estimated home deliveries (00's)	Percentage ch-nge 1965 on 1959
Washing machines ...	1,500	+38
Refrigerators	1,250	+50
Vacuum cleaners ...	1,500	+ 6
Space heaters	4,600	+60
Irons	1,900	+10
Cookers	600	+26
Immersion heaters ...	1,100	+57
Hair-dryers	450	+10
Wash-boilers	220	+13
Water-heaters	220	+21
Toasters	190	+10
Floor-polishers	25	+ 9

These estimates must be treated with some reserve. The sales growth of the more costly items, including space heaters, will be affected by fiscal and credit control policies as well as by new housing developments and other factors beyond the industry's control. Any of these factors can invalidate the above estimates in detail but the overall picture seems likely to show that the total output of our domestic electrical appliance industry will be £240 millions by 1965 and approaching £340 million by 1970.

The import-export position will have an important bearing on this. Until credit controls were suddenly removed in 1958 competition from imports was not important. Since then they have been considerable, amounting to £11,000,000 in 1959 and £12,000,000 in 1960. The leading supplier has been W. Germany, other major suppliers being Sweden, Italy, Netherlands and the U.S.A. On the other hand W. Germany is our best export market for domestic washing machines and one of our good markets for domestic appliances generally. Reciprocal trade between countries with high living standards seems likely to be an important factor in the future pattern of the domestic appliance business. In 1960 exports rose to £33,000,000, 27 per cent over the previous year. For the industry to maintain this growth and play its full part in exports it must clearly match the design, prices, and sales techniques of competitor countries. It is necessary to keep in mind that the maintenance of a competitive export performance rests equally upon the solid foundation of reliable home sales, as upon energetic and enterprising sales effort overseas.

This appraisal of the future demand has, for reasons of space, been confined to two main sectors of the electrical manufacturing industry but the use of electricity is so closely related to the economic growth of the country that an examination of almost any sector would present a similar picture of technical progress and expansion.

The Role of Trade Associations

In the early days the driving force of many trade associations was the need to defend their members against the effects of an unstable economy and unregulated foreign competition. Today, although the basic purpose of a trade association remains the same, the needs are different and call for a much wider range of services. For instance, the Restrictive Trade Practices Act has a direct bearing on the future of trade associations in that it defines and limits the extent to which co-operation between manufacturers is permissible without registration and ultimate reference to the Court.

There is an increasingly dynamic element in competition in electrical manufacture today which is due to causes quite apart from the operation of the R.T.P. Act. Import controls and tariffs are coming down at home and abroad and there is the terrific pace of techological advance which is the outstanding characteristic of the mid-twentieth century. To compete successfully, British firms must be well informed about market changes, competitors' developments and production capacity. For much of their day-to-day information firms must inevitably be self-reliant. It would be wrong, and indeed impossible, for a trade association to try and provide the detailed commercial information which comes through the direct contact of firms with their markets. Nevertheless the whole field of the collection and dissemination of statistics and information, the study of trends and overseas competition, should form a major part of the work of a modern trade association. One of the chief causes of excessive price warfare and unstable trading conditions is lack of reliable information. Ignorance of such matters as prevailing price levels and costs, the general trend of enquiries and orders and the existing capacity to produce, can and does distort judgment and hamper long term planning. It is not easy to prevent this completely but the interchange of information between firms in the same industry under conditions of trust and confidence can go a long way towards it.

In addition to information of this kind, which can only be secured through full co-operation of member-firms, there is a wide field where it is much more economical for the information to be provided for an industry by its trade association. The BEAMA Survey of the European Common Market, the first of its kind to be undertaken by a trade association, has already proved its worth and has attracted much favourable comment. The services offered by the BEAMA over the whole field of information seem likely to provide the basis of co-operation in the electrical manufacturing industry in the future.

[Mr. Steward then mentioned some of the other services offered by BEAMA to industry in relation to contract conditions, technical standards and education].

Another function of a trade association which has grown in importance in recent years is that of public relations. This covers relations with the Government and the nationalised industries as well as the formation of public opinion. One of the most striking developments of recent years has been the increasing interdependence of Government and industry and the growing importance of Government decisions on industrial planning and development. The trade association provides the essential channel of contact, information and, most important from the industry's point of view, interpretation. At the same time the trade associations are of benefit to the Government itself firstly, as an informed and informal point of contact on industrial matters and, secondly, as a representative and informal channel of communication with industry.

The Microcircuit Concept

Microminiaturisation of electronic circuits and components was among the subjects discussed at an International Conference on Components and Materials held at the Institution of Electrical Engineers in London from June 12 *to* 16. *The following abstract of a paper presented during the conference by Mr. D. I. Gaffee, of Mullard, Ltd., outlines the different approaches to this objective and deals with the application of the microminiature concept to an integrator for a missile.*

THE combined development of printed wiring and transistor circuits has resulted in a major transformation of the methods of construction, and to-day complex equipment is being produced in small sizes impossible to achieve by earlier techniques. The need for even smaller equipment for use in missiles, satellites and in computers, especially where high speed is needed, has led to a further advance in constructional techniques, namely microminiaturisation.

Broadly speaking there are currently three main approaches to microminiaturisation :

Micromodules.—These are essentially active and passive components on small thin notched ceramic wafers. They are stacked together and connected by riser wires which make the circuit and form a rigid structure.

Microcircuits.—These are substrates on which the passive elements have been deposited, and which have active components attached either to the surface or set into holes in the substrate.

Solid-State Circuits and Functional Blocks.—In this approach a single piece of semiconductor material is etched, doped, &c., to obtain the desired electronic operation. In the functional block approach there need be little correlation between the semi-conductor functions and the conventional circuit representation.

The micromodule technique is attractive to the circuit designer since it enables him to think of the problems in terms of conventional components. However, it is limited in scope in several ways. The number of soldered joints necessary are at least as numerous as in conventional equipment and hence the ultimate reliability obtainable may be limited. There are considerable design difficulties to be overcome since only straight riser wires may be used between modules. This can be eased in some circuits by using special conductor wafers designed to provide cross connections. The packing density is limited using single-component micromodules, but may be increased by using multi-component wafers i.e. simple microcircuits. However, this technique cannot be extended indefinitely since the number of component combinations required by the circuit designer are prohibitive. Finally, assemblies of micromodules may be more expensive than their conventional equivalents since the requirements of high reliability and the difficulties of assembly are not easily satisfied.

The microcircuit concept requires the close collaboration of the system designer and the component manufacturer if the basic objectives of high packing density, high reliability, &c., are to be achieved simultaneously. The problem of high power dissipation can be overcome by suitable circuit designs and by careful disposition of any heat sources on the substrate. Many of the problems en-

countered owing to the small size of the components are overcome in the microcircuit, since all the passive components are manufactured *in situ* without the necessity for further interconnection on the substrate. The higher costs involved in the efforts to achieve high reliability may also be largely offset, since the cost of manufacturing a complete passive microcircuit may not be very different from the cost of using individual high-quality components and the additional cost of assembly.

Solid-state circuit design offers very interesting possibilities for the future, but at the present time it is not possible to estimate when it may be effectively used in the manufacture of complete equipments. The logical first stage in its evolution would seem to be in combination with the microcircuit where it may replace some of the simpler circuit functions.

In the light of the above considerations it was concluded that the microcircuit was at present the most satisfactory solution to the problem.

Example of Microcircuit

The equipment chosen to be a test vehicle for the techniques was a digital integrator for use in a missile. This was required to have a packing density of the order of 300 components per cubic inch and an overall volume between 8 and 10 cubic inches. The integrator is built from several sub-units, each being a throw-away unit in case of failure. These sub-units may contain as many as 100 transistors and associated circuits. Thus in this particular application replacement of single substrates will not be necessary, although in any more general application this facility would almost certainly be required. The power dissipation in this circuit is of the order of 5mW per stage, and consequently no difficulties due to heating are expected.

The transistors and diodes used in the microcircuit must be compatible with the thin substrates used, capable of production in large numbers and of achieving a very high degree of reliability. These requirements may be satisfied by a transistor in a hermetically sealed flat metal can. In this way high reliability can be achieved by encapsulating the active element in an inert atmosphere, and hence surface changes due to moisture, &c., are prevented. A great deal of flexibility of choice of active semiconductor element becomes available as many of the active elements already available as full-size transistors may be encapsulated in the microminiature can.

The thickness of the can is 1·25mm and the overall diameter 3·1mm. The emitter and base leads are on the upper surface of the can and enter it via glass–metal seals. The leads protruding through these seals are bent through 90 deg. to lie close to the upper surface of the can and are both held in position and insulated from the can by a thin resin film. The collector pellet of the transistor is in electrical contact with the can in the construction used and hence the collector lead is spot welded to the top surface of the can.

Large numbers of these devices have been produced and have proved to be extremely robust. No difficulties have been experienced in soldering these into microcircuits despite the fact that leads as short as 1mm beyond the edge of the can have been used.

Transistors in Production

At the present time, microminiature versions of the type OC45 transistor and type AAZ12 diode are being produced. These were chosen to enable one version of the microcircuit digital integrator to be built and to enable the problems of encapsulation to be studied and solved. Microminiature silicon transistors are already in the development stage, and now that the encapsulation problem has been solved, in principle any transistor or diode with a suitable wafer size can be produced in the microminiature can.

Passive Components

The prime consideration in the design of passive microminiature components must be reliability.

All the passive components are produced by vacuum deposition of metals and dielectrics on thin glass substrates through masks which define their geometry. After deposition of the passive components, the transistors and diodes are soldered in position and the assembly of wafers encapsulated to form a complete equipment or sub-assembly.

The value of a resistor is governed by the material used, its thickness and its geometry, and consequently a wide range of resistances can be produced by simply varying the shape and size of the patterns. Capacitors are produced by evaporating a metal-base electrode, which is then covered by an evaporated dielectric layer and the top electrode is deposited on to this. The capacitance depends on the dielectric, the thickness and the area of the electrodes.

The choice of substrate material is of major importance and has been the subject of intensive investigation. Ceramics and glass appear to be the most suitable materials. The substrate must have the following attributes : the surface must be smooth and reproducible ; the material of the substrate must be chemically and electrically inert ; and it must be readily available in the form required. Certain kinds of glass closely approach these requirements and consequently glass has been used as substrate material for the microcircuit.

Alderson and Ashworth investigated the properties of nichrome films as resistors and evolved a technique for their production. This basic method has been extended to enable microcircuits containing close-tolerance resistors to be manufactured. At the present time resistors can be manufactured with 5 per cent tolerances (without adjustment by scribing, &c.) and with temperature coefficients of the order of 100 parts in 10^6 per deg. Cent. It is difficult to specify the power rating of these resistors since so much depends on the exact disposition of the resistor in the circuit. However, one way of defining this is to specify the dissipation per square centimetre of film and, in fact, resistors dissipating 4W per square centimetre have been running at room temperature and high ambient temperatures without showing any sign of deterioration to date.

Conductors and Connections

The main requirements of a conductor are low resistivity in thin-film form, good adherence to the substrate and suitability for interconnection using soldering techniques, &c. The most suitable conductor materials for microcircuits are gold, copper and nickel, although many other metals may be used. In all cases it is necessary to use an intermediate metal such as chromium, which acts as a bonding agent between the glass substrate and the conducting film.

Connection to microcircuits is best made by soft soldering tinned-copper wires direct to the conducting films. In this way very strong joints have been produced, the wire being the most frequent point of failure found under severe mechanical test conditions. Special attention must be paid to the conductors in series with evaporated capacitors when used at high frequencies, since a considerable increase in power factor can occur owing to high resistance of the conductor.

There are many dielectrics which may be potentially useful in thin-film capacitors, and long-range investigations of some of these are in progress. However, most work has been carried out using silicon monoxide as the dielectric and the properties of these will be described.

The capacitances in the microcircuit are controlled by the thickness of the dielectric film, its permittivity and the area of dielectric between the electrodes. Typical capacitors have been made with values of the order of 0·01 μF per square centimetre and with power factors of 0·1–1 per cent at 1500 c/s and d.c. leakage resistances of $10^9\Omega$. The capacitance per square centimetre can be varied if required (by varying the thickness of the dielectric) from approximately 0·001 to 0·03 μF per square centimetre, the other parameters staying more or less constant ; the main difference is that the working voltage of the thinner dielectric is lower.

Interconnection and Encapsulation

There are a very large number of ways in which conventional printed-wiring circuits have been interconnected and without much effort it is possible to devise even more. The method in use at present for connecting to a microcircuit is to soft solder a fine tinned-copper wire on to conducting lands at the edge of the substrate. Soldered joints can be made either by using an electric iron with a very small bit or by a non-contact heating method such as the use of a hot-air jet. Joints made by both methods are extremely robust and are electrically excellent. Since the soldering is done using carefully prepared wire and freshly evaporated films, the possibility of a dry joint is very remote, and so far no dry joints have been produced.

Alternative methods of connection to the microcircuit are thermo-compression bonding and ultrasonic welding. These produce joints which are inferior mechanically to the soft-solder joint, although electrically excellent. It will be necessary to study these for a considerable time before they can be considered as real alternatives to soldering in this application.

Interconnections between microcircuits may be made using printed-wiring techniques, separate wires (as in the micromodule system), or some similar method. Several digital integrators are to be made and hence more than one method of interconnection may be used, one of which will be printed wiring. In general, the precise method used must depend on the degree of complexity of the equipment, the degree of miniaturisation necessary and on whether replacement of single microcircuits will be required.

Encapsulation will be of two basic types, single microcircuits and sub-assemblies of microcircuits. For single microcircuits the method used may depend on the application and could range from sealing each microcircuit in a flat glass envelope to coating with a suitable resin or potting medium.

Sub-assembles of microcircuits may be encapsulated in a metal can using glass-metal seals for electrical connections and full hermetic sealing with perhaps a filling of an inert gas. Alternatively, it may be necessary in some applications to use a potting medium in the can both to support the substrates and to absorb shock and vibration.

LETTERS AND LITERATURE

Letters to the Editor

MILLIONS TO BE SAVED ?

SIR,—In the case of the Midland and Great Northern line in Norfolk Mr. R. J. Harbach gives the figure of £40,000 as the average cost per mile for conversion into a highway.

However it must be taken into consideration that Norfolk County Council plan to build a 24ft wide road with 8ft verges on each side so that the minimum width of right of way will be 40ft.

In the summer of 1960 I measured the M. and G.N. in several places and for the most part the right of way between fences is only 30–33ft wide compared with disused single- and double-track railways in Yorkshire which are about 45ft wide.

This means that the Norfolk conversion scheme includes the price of a strip of agricultural land at least 7ft wide. One would expect this land to be more expensive per square foot than the disused railway land but I understand that instead of British Railways selling for £1000 per 10 acres (1 mile), which is what Norfolk County Council expected, basing their estimates on adjoining land values, they are now asking ten times as much. This seems a very short-sighted policy considering the fact that disused railway land is useful for few other purposes besides road building and generally only sells for £60 per mile in England and £30 per mile in Scotland.

In Southern France they seem to be more enlightened and at Vence there is the remains of a single-track railway which had several of its viaducts destroyed by the Germans. However the French have used both viaducts and tunnels, which are only 13ft wide (4m) and laid a road surface which has produced a very good secondary road (see accompanying engravings).

It is a great pity that we have not used our disused single lines in a similar fashion. Even when we have an excellent opportunity such as the 3⅜-mile long Nottingham suburban railway which is double-track with 25ft wide tunnels, we turn it into a rubbish dump and destroy the bridges ! An article on this line appears in the June, 1961, issue of the *Railway Magazine* and I think your readers would find it very interesting, particularly if they were to see for themselves what a horrible eyesore has been made out of this valuable piece of real estate !

To convert this into a motorway would probably cost a good deal more than £30,000 to £40,000 per mile average for conversion but it would certainly take plenty of traffic as the surrounding districts are so heavily built up. Its use would increase even faster when the other Great Northern lines were converted and they in turn connected with the Great Central. The latter being the obvious choice on which to start main line conversion.

A. I. WATKINSON

Harrogate,
June 13, 1961.

SIR,—I have read with much interest your editorial comment on the lengthy correspondence on railway conversion and appreciate the note of realism which you have struck. Perhaps as representative of the body from whose initiative the correspondence arose I may be allowed a final word ?

We in the Railway Conversion League can understand, even if we cannot share, the desire of many—yourself included—to see a revival in the fortunes of the railways. These have served the country well during the lifetime of all of us ; but just as there comes a time when loved and admired parents must hand over to the younger generation, whose outlook and methods will not be the same, so we believe that the country must now accept the passing of the railways.

If the preservation of railways were to be made an over-riding objective, it could no doubt be achieved—at a cost ; but should not the over-riding objective be the solution of our traffic problems and the establishment of the best possible traffic system for our needs ? If so railways could only claim a right of survival if this was based on a demonstrable superiority of service over a wide range of traffic. Does this superiority exist ? We do not think so.

The idealistic solution of a happy partnership of road and rail is illusory. We cannot in practice, tear town and country apart to the extent which would be necessary to relieve present road congestion and provide for future traffic increases. If we could, and did so, it would only mean the final eclipse of railways, whose hope of survival lies in an increasingly congested road system. The only possibility of achieving safe and efficient road traffic is in developing the existing railway network as a system of segregated roads.

As there is no room for both and new and the old, the only practical course, as we in the League see it, is boldly to combine the splendid routes of the railway network with the splendid vehicles of to-day, welding the two into a new system worthy of the age.

M. J. DOUGLASS

Hon. Co-ordinator,
Railway Conversion League,
Shamley Green,
Guildford, Surrey.
June 16, 1961.

SIR,—I do not believe Mr. Walker (March 3) ever wrote a truer sentence than " road transport pays nothing like enough in taxation to cover all the direct and hidden costs of the services provided." Here is an example taken in Lausanne, Switzerland.

A public place with seats, playgrounds, telephone, &c., was converted into a free parking space, thus providing great inconvenience to the population. In the vicinity, a house with three apartments in good condition was purchased by the city for about S.Fr.8000, and demolished for S.Fr. 4000, to provide free parking space for four cars. These four cars pay circulation taxes to the State, the city receives only a property tax of about S.Fr.5 from each. Thus the city receives S.Fr.20 and, having to borrow the S.Fr.12,000, pays S.Fr.360 as interest. Nobody speaks of the loss of S.Fr.340 every year.)

As the aim of the R.C.L. is the suppression of railways, I wish its leaders could, before going too far, investigate the situation in Venezuela. Before 1954, there were many railway lines, some British owned, like Caracas–Ocumare, Caracas–Guayra, Tachira, &c. The trains were on time, clean and spacious. Some minutes before the start, a policeman inspected the carriages, and if somebody could not be seated, a carriage had to be added.

Now the bus, dirty and crowded, is king. No time schedule. You see, in the morning, a bus with an inscription : " Barquisimeto. I am going." You pay and you enter. But you have to wait till the bus is full, perhaps till evening. No question to have your money back, you have no ticket, no receipt. On most buses with normal price the patients are seated with the knees just below the chin.

I remember a case, between Barquisimeto

Converted single line railway near Vence in France

and Valera, when the driver stopped in the open country on the sign of a woman waiting there. This lady had no money, but wanted to go to Valera. After a discussion, it was agreed that she would pay her fare by providing the driver with a meal. Then we had to wait till the meal was ready and eaten, and the woman ready. In another case, we had to wait in Valera from noon to evening, because the driver was tired.

If this situation is the aim of the R.C.L., then there is really nothing more to hope from man.

RENÉ P. CHAUVET

Hilla,
Iraq.
June 2, 1961.

SIR,—In the American journal *Civil Engineering* for March, 1961, an article by Mr. V. E. Gunlock, chairman of the Chicago Transit Commission, described the results of eighteen month's operation of that city's new Congress Expressway.

The Expressway consists of a highway with four lanes in each direction (which cost 10,000,000 dollars per mile) plus a rapid-transit electric railway with one track in each direction (which cost 4,000,000 dollars per mile). A photograph of part of the system showed that the railway at its widest point (a station) occupies about the same width as one carriageway of the road.

Mr. Gunlock stated that the highway carries about 7500 passengers per hour in the peak direction and is operating at or near its design capacity ; the railway is operating at only 30 per cent of its capacity (both longer and more frequent trains could be run) but already carries 10,000 passengers per hour at peak loading. A count of passengers over a fifteen-minute peak period in May, 1960, showed that the railway passed 3100 people compared with 1400 on the road.

These figures are hard facts of what is being achieved, not fanciful theories such as we hear from the Railway Conversion "crusaders." They clearly show where the millions are to be saved : by providing a modern up-to-date railway system, as quickly as possible.

P. T. MOORE

Middlesbrough,
June 8, 1961.

CREATIVE ASPECTS OF ENGINEERING DESIGN

SIR,—Professor Francis has suggested that the studies in engineering which are pursued at British Universities are not necessarily those which will provide the best grounding for real life. He especially regrets the absence of any fundamental training in design, pointing out that in countries where such training is given, such as Germany, the standard of accomplished engineering work is higher than in this country or U.S.A.

Complaints that British engineering education is incomplete are by no means new. Even 100 years ago inferior technical education was alleged to threaten the industrial interests of Great Britain, a situation which the Council of the Institution of Civil Engineers felt it their duty to investigate. In their report[1] they sought to allay criticism by dividing the education of a civil engineer into two parts. The first of these, a theoretical training in natural science, was not held to be strictly essential. Practical training in the arts of design and construction was alone regarded as the foundation of an engineering education. Such training, obtained as the pupil of a practising engineer, was thought to be better managed in this country than elsewhere. The superior theoretical eduation given to Continental engineers at that time was acknowledge but discounted as unimportant.

In more recent years the importance of sound theoretical knowledge has been recognised and the responsibility for imparting it has become that of the universities. But at the same time the old system of fee-paying pupilage has virtually disappeared. The practical training which was the pride of our predecessors has nowadays to be picked up piecemeal in employment. Thus the balance of education has reached the other extreme, where science has almost entirely displaced art. One consequence seems to be that British engineers have largely abnegated their responsibilities for creation and innovation in such matters as the enclosure of space. As Professor Francis has written "The engineer limps along behind . . . when he should be the pioneer of structural form."

An obvious solution of these difficulties consists of the establishment of professional courses in engineering of the kind which are common on the Continent and which are currently being considered in U.S.A.[2] We are already accustomed to such courses for medicine, dentistry and architecture within our own universities. It would be necessary to add to the existing scientific training much broader studies in the principles underlying design and construction. These must entail a further two years of study for a professional degree, thus giving the engineer the same length of formal training as the architect or medical practitioner. Three year courses in engineering science might remain, just as similar courses in medical science co-exist with the professional courses in medicine in some universities to-day.

There will be two main objections to such a proposal. The first is that the demand for graduates of our existing engineering science courses is so great at present that no extension of courses could be contemplated. But, as Sir Herbert Manzoni pointed out in his recent Presidential Address to the Institution of Civil Engineers, it will not become easier to make such a change in the future. Any change should be made now. That changes of this kind can be made is demonstrated by the increase in the length of teacher-training courses at a time of serious shortage.

The second probable objection is that the non-scientific aspects of engineering are best taught in actual practice. While this may be true in principle, Professor Francis has pointed out that there is often little time for the thorough investigation of alternatives in the modern design office. He writes "The vital initial stages are dismissed with one wild stab at the solution ; and the final decision is a mockery of what it should be, with 'what was done last time' looming large in the answer." Granted the present desire to train large numbers of engineers, it seems only efficient to do so under controlled conditions in professional schools.

The prosperity of this country, both now and in the future, depends to a considerable extent upon the ingenuity and imagination of its engineers. It is absurd to deny them the reasonably balanced and complete training which is already provided, at the public expense, for other professions. Last year, in a Third Programme broadcast, Mr. Austen Albu described "The Price of Tradition in Industry."[3] It may well be said that the anomalies to which Professor Francis has drawn attention are the price of tradition in engineering education.

GEOFFREY BROCK, Ph.D., A.M.I.C.E.
13, Catholic Lane,
Sedgley, Worcestershire,
June 17, 1961.

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[1] The Education and Status of Civil Engineers in the U.K. and Foreign Countries, Institution of Civil Engineers, 1870.
[2] Civil Engineering Education, American Society of Civil Engineers, 1961.
[3] "The Price of Tradition in Industry," Austen Albu, M.P., *The Listener*, December 8, 1960.

SIR,—Your articles on "Science and Design in Engineering Education and Practice" are on a subject of the greatest importance. You are to be congratulated on giving them prominence. Some years ago when I realised how different were the methods of educating mechanical engineers in different countries, I started collecting material, some of which is to be published as a book, *Design and the Education of Mechanical Engineers*, by Sir Isaac Pitman and Sons, Ltd., later this year. Since so much has been written in the book which will be on the market shortly, I would only like to suggest that the standard of design work carried out in Technische Hochschulen and European Universities is far from being uniformly "badly done."

F. SLAUGHTER

Senior Lecturer in Mechanical Engineering, Glamorgan College of Technology,
Treforest.
Cardiff,
June 13, 1961.

Book Reviews

Direct Conversion of Heat to Electricity. Edited by J. KAYE and J. A. WELSH. John Wiley and Sons Inc., New York. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 70s.

THE direct conversion of heat into electricity has for a long time been the pipe dream of physicists and engineers. Small-scale experiments date back to the last century. Meanwhile, the power engineer has been steadily improving the design of rotating machinery and steam generation plant. A stage has been reached however where significant increases of boiler temperature can no longer be contemplated using steam as the working fluid. Further improvements thus demand new approaches and it is with these factors in mind that effort is being applied to looking at less conventional approaches which may allow higher operating temperatures to be considered. This activity has been further stimulated particularly in U.S.A. by the needs of space research where small direct conversion units would be of value and where studies of magnetohydrodynamics and plasma engines are being carried out for reasons other than power conversion.

To meet the needs of the growing number of engineers and physicists who were entering

this field a special Summer School was opened at Massachusetts Institute of Technology in the summer of 1959 and this book contains the material on which the lectures were based. The book is divided into five sections covering :

Section A (five chapters) " Thermionic Engines—High Vacuum."

Section B (six chapters) " Thermionic Engines—Low Pressure."

Section C (two chapters) " Magnetohydrodynamic Converters."

Section D (nine chapters) " Semiconductor Devices."

Section E (one chapter) " Fuel Cells."

Of the twenty-three chapters, fourteen are substantially reprints of material published previously elsewhere ; some of these have been adapted slightly to the present publication. However, the collection makes a useful one together with papers which have not been published before. Inevitably in a collection of this kind there must be considerable repetition and an unevenness of style, but each chapter concludes with a list of symbols used and this goes far to make up for divergences in nomenclature between authors.

It is seen from the number of chapters that thermionic engines and semiconductor thermoelectric engines occupy the lion's share of the book. For those who wish for a general introduction to thermionic engines the chapter by V. C. Wilson is to be commended. It is a model of clarity in exposition and in ten pages it summarises the physical principles involved and points to the problems and potential usage of diode devices. The chapter on the magnetic triode is interesting in that it is one of the first detailed papers on the topic to be made generally available. It is, however, a theoretical paper and, although hinting darkly about experimental difficulties, does nothing to explain to the layman why this device is not being more actively pursued.

The paper by Hatsopoulos on " Thermodynamics of Thermionic Engines " conveniently bridges the gap between the thermionic engine (frequently called the plasma thermocouple) based on the Edison effect and the thermoelectric engine or thermocouple based on the Seebeck effect. A figure of merit is derived for the plasma thermocouple and can be compared directly with those obtained using thermoelectric semiconductors.

Turning to thermoelectricity, the chapter by Jaumot provides a comprehensive review of the basic principles and of the status of materials development, though from the latter point of view it is already rather outdated. There is an admirable treatment of the thermodynamics of thermoelectric generators by Hatsopoulos and Keenan. Three chapters deal with the design of thermoelectric generators, special reference being made to the use of lead telluride thermojunctions. Similarly, the design of a thermoelectric refrigerator is discussed with reference to bismuth telluride junctions. The very elegant method, devised by Harman for determining the parameters of a thermoelectric material, is explained and the corrections due to heat radiation are analysed. A paper on the effect of oxide impurities is interesting but seems rather out of place.

Magnetohydrodynamic conversion is still in its infancy and the two chapters reflect the formative stage of 1959. The paper by Rosa and Kantrowitz is a general introduction to the problem, giving general trends and problems which will occur to workers starting in this field. There are also included some striking photographs of the flow of high-speed ionised gases under the influence of magnetic fields. The paper by Carabateas is a theoretical analysis of a particular problem using irrevisible thermodynamics.

The paper on fuel cells by Yeager summarises their status at that time. Fuel cells differ from the other devices in the book in that they do not involve the Carnot cycle, and one feels that this chapter has been put in at the end as a concession to completeness by editors who are primarily interested in the thermodynamics of heat engines. The extensive bibliography attached to this chapter indicates that to dismiss the subject in fourteen pages is somewhat cavalier treatment of work which could command a book of its own.

Summarising, then, we have here a useful collection of papers covering a large number of aspects of this rapidly growing subject. It will certainly be welcomed by the specialist in this field and is recommended for selective reading by power engineers who wish to know what techniques may supplement or compete with the conventional methods of converting heat into electricity.

An Introduction to Sewage Treatment. By C. LUMB, F.R.I.C.S., F.Insts.P., The Institute of Sewage Purification, 10, Cromwell Place, South Kensington, London, S.W.7. Price 10s.

THIS forty-five page book is intended to give, in non-technical language, an outline of the processes involved in " converting the original very polluting liquid . . into an effluent resembling much more nearly a natural water," as Dr. B. A. Southgate, director of the Water Pollution Research Laboratory, says in his foreword. The book is divided into ten chapters, each dealing with one aspect of the subject, or process, and is illustrated with diagrams and photographs drawn from sewage treatment works, both large and small, in all parts of the country. Although the author is aiming his remarks at " student nurses studying hygiene and sanitation, schools' civic classes, and members of the public wishing to understand the principles of this essential local government service," he has given quite a thorough treatment to his subject, even within the limits of this booklet, and the technically-minded who have never been concerned with this subject will find his description educational, and to the point.

Management Training, Aims and Methods. By R. J. HACON, B.Sc. (Econ.). The English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 17s. 6d.

WHETHER it is possible satisfactorily to train people for managerial posts is open to question, but Mr. Hacon is evidently of the opinion that it can be done and advocates a training department in business organisations. His object is " to build bridges between those mainly interested in social theory and management research and those seeking to improve the every-day performance of individuals, and work groups in industry and commerce."

This book is divided into three parts, the first of which deals with the scope of training, the second includes, among other things, lectures, films, case studies, and group development, while the third is devoted to theory and practice, and discusses such subjects as co-operation, leadership and continuity, and finally looks on to new horizons in training.

The author places a caption at the head of each chapter, an example of which is that on Projects and directed Exercises which reads : " make it vivid, make it memorable, make it relevant " and he certainly does his best to follow his own advice. Too often it is considered that a course of lectures suffices to fit a foreman for a post on the management, but it is agreed that this is not so, for a man should be offered opportunities of filling temporarily vacancies caused by sickness, holidays, &c., before being appointed to a post on the management. While it can be accepted that it may not be right to say that " managers are born and not made," natural aptitude is a great asset.

There is much that is suggestive in this work but not much that is controversial, as the author is setting out clearly his own experiencies, without bias, and the book can safely be recommended to any who are interested in the important subject of training for management.

Books of Reference

Metallstatistik 1949–58. Published by Metallgesellschaft A.G., Reuterweg 14, Frankfurt/Main. Free on request.—The forty-sixth edition of *Metals Statistics* reviews the years 1958 and the first half of 1959, and quotes production figures and prices for world and national production of the principal non-ferrous metals and certain semi-products during 1949–58.

Commercial Dictionary. Concise dictionary of Commercial Expressions, English–Russian and Russian–English. The British Iron and Steel Federation, Steel House, Tothill Street, London, S.W.1. Single copies free on request.—As a practical contribution towards the present trade drive between the United Kingdom and the Soviet Union, the British Iron and Steel Federation has prepared a 142-page glossary of commercial expressions in its series of concise pocket dictionaries. This new issue covers a wide range of terms and phrases likely to be needed in business correspondence connected with most branches of trade and industry. Previous publications in this series comprise illustrated glossaries of iron and steelmaking technical terms in French, German, Swedish and Spanish, and a similar glossary in Russian which covers the continuous casting process.

Books Received

Aircraft Instruments. By C. A. Williams, Odhams Press, Ltd., 96, Long Acre, London, W.C.2. Price 35s.

Mine Ventilation and Air Conditioning. By Howard L. Hartman. The Ronald Press Company, 15 East Street, New York 10, N.Y. Price 12.00 dollars.

Modern Furnace Technology. Third Edition. By H. and G. Etherington. Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C.2. Price 120s.

Thermodynamic Functions of Gases. Volume Three. *Ethane, Methane, Nitrogen*. Edited by F. Din. Butterworths, 4 and 5, Bell Yard, London, W.C.2. Price 63s.

Tensor Analysis of Electric Circuits and Machines. By L. V. Bewley. The Ronald Press Company, 15 East 26th Street, New York 10, N.Y. Price 12.00 dollars.

Field Theory for Engineers. By Parry Moon and Domina Eberle Spencer. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 96s.

Introduction to the Dynamics of Automatic Regulating of Electrical Machines. By M. V. Meerov. Butterworths, 4 and 5, Bell Yard, London, W.C.2. Price 100s.

An Introduction to Servomechanisms. By F. L. Westwater and W. A. Waddell. The English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 15s.

Atlas of the Other Side of the Moon. Edited by N. P. Barabashov, A. A. Mikhailov, and Yu, N. Lipskiy. Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 50s.

Fire Board: The Problems of Prevention and Control in Ships and Port Installations. By Frank Rushbrook. The Technical Press, Ltd., 112, Westbourne Grove, London, W.2. Price 63s.

Engineering Laboratory Work—Part 2—*Materials and Machines*. By S. R. Oulsnam and B. G. Brothers. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 18s.

International Construction Equipment Exhibition

No. II—(*concluded from page 993, June 16.*)

The first Internationl Construction Equipment Exhibition was opened by Mr. Reginald Maudling, President of the Board of Trade, on Thursday June 15. The exhibition is at the Crystal Palace in South London, and includes not only a comprehensive display of equipment on the stands of the many firms exhibiting, but also two proving grounds where earthmoving plant can be seen in action. The exhibition closes tomorrow.

IN these notes we conclude our review of the Crystal Palace exhibition, by describing one or two more examples selected from the very comprehensive range of plant and equipment of all kinds which is to be seen there.

Robert Hudson Ltd.

The heading illustration above shows the "Leedsall" dumper-trailer, known as the "Super Four," which is powered by a four-wheel-drive Fordson Super Major or similar tractor. The machine is distributed by Blackwood Hodge, Ltd. Its capacity is 7 cubic yards, (i.e. a rated capacity of 20,000lb) and the tractor horse power is 51·8 b.h.p. at 1600 r.p.m. It is of interest that this is the third machine of this general class recently introduced and described in these columns. The linkage between tractor and trailer is similar in principle to that of the Shawnee-Poole dumper, which we described and illustrated last week. The third example, the "Morewear" dumper, which is also to be seen at the exhibition, was described in The Engineer of April 7 last, page 563. The "Leedsall" machine differs from its competitors in that there is no goose-neck in the linkage, which however, is articulated in all directions with 90 deg. swing in either lock, thus giving a turning circle of less than 30ft.

Fig. 4—"Rotaplacer" hydraulically-operated concrete placing dumper which can discharge through 180 deg. about the front end of the machine and up to 4ft above ground level

C. H. Johnson (Machinery), Ltd.

The dumpers and skip handling equipment of C. H. Johnson (Machinery), Ltd., Stockport, Cheshire, includes the recently introduced "Rotaplacer" shown in Fig. 4. This machine comprises a rotatable, hydraulically-operated skip mounted on a similar chassis to one of the firm's "Twin/65" 1½ cubic yard dumpers. The 20 cubic foot skip, which has a heaped capacity of 40 cubic foot is of "funnel" design with an effective pouring lip. It is rotatably mounted on a ring on the chassis of the machine through a sub-frame and at the top is pivoted to the ends of arms extending from the sub-frame. A hydraulic ram, connected between the frame and the bottom of the skip, is extended to tip the skip.

The sub-frame with which the skip rotates has a notched plate in its base and a lever-operated pin engages in the notches to lock the rotating skip assembly in the required position for the tipping operation. Turning of the skip assembly is effected manually and does not call for undue effort on the part of the operator of the machine.

Massey-Ferguson (United Kingdom), Ltd.

Four new tractors together with ancillary equipment have been introduced by Massey-Ferguson (United Kingdom), Ltd. The new M-F 203, which supersedes the 702 industrial tractor (The Engineer, October 2, 1959), is the basic power unit for the 710 digger and the makers' 702 shovel. It is powered by the Perkins three-cylinder diesel engine, which develops 39·6 b.h.p. at a governed maximum speed of 2000 r.p.m., and has a maximum torque of 117·3 lb ft at 1300 r.p.m. When operating the 710 digger and 702 shovel, a hydraulic pump mounted forward of the engine is driven through a flexible drive from the crankshaft pulley, the pump drive shaft passing through the tubular front axle pin.

The new tractor has a one-piece, non-adjustable front axle of heat treated cast steel and incorporates a tubular trunnion pin. At the front of the tractor is a heavy steel "bumper" casting, surrounding a $\frac{3}{16}$in thick steel grille which protects the engine radiator and the front-mounted hydraulic pump. A steel plate beneath the front casting shields the engine sump from possible damage.

The hydraulic system incorporates the Ferguson principles of implement control. Disc transmission brakes located on the inner ends of the rear axle half shafts, have a combined braking area of 207·4 square inches. Power steering is standard equipment, and differential lock can be fitted if required.

The new M-F 205 industrial tractor is basically identical to the 203 model apart from the addition of a torque converter unit and a hydraulically operated direction reverser or "shuttle transmission" which allows movement of the tractor to be changed from forward to reverse, and back to forward, without the need to change gear.

The shuttle transmission, situated between the torque converter and gearbox, comprises two hydraulically-operated multi-plate friction clutches a common output shaft. A number of clutch plates are in engagement with the drum or outer-member of

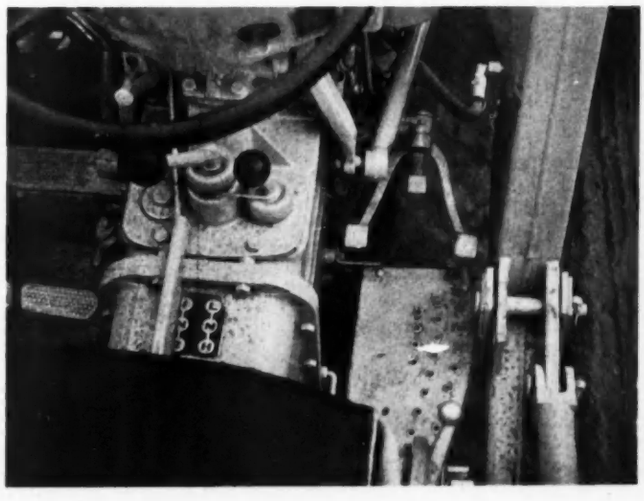


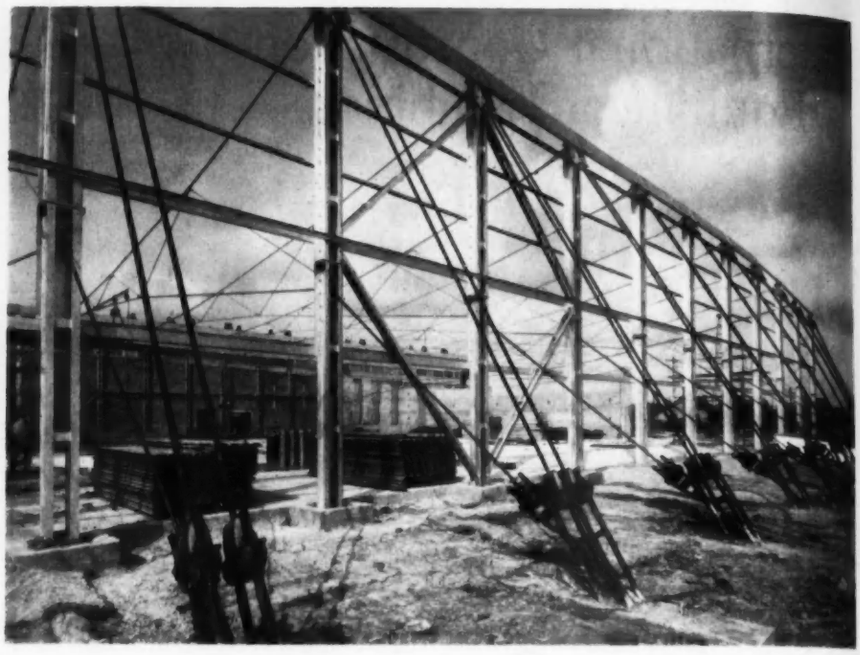
Fig. 5—Pedal arrangement for "shuttle" transmission of Massey-Ferguson tractor

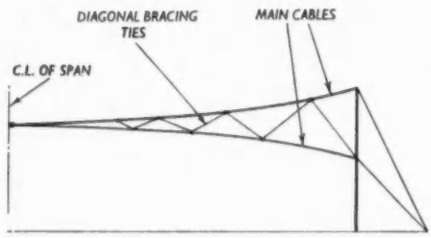
Rigid Cable Roofs

A development of a rather different character from the others we have described was exemplified at the International Construction Equipment Exhibition by models and by the construction of the exhibition stand of British Ropes, Ltd. This firm is introducing into this country a structural technique which uses wire ropes in such a manner that they form a rigid roof structure. A number of such roofs have already been erected on the Continent, the system being known as the Jawerth system, after its originator who is Swedish. Basically, the system comprises a "truss" of ropes pretensioned so that every member of the "truss" remains in tension under all conditions of working load. Thus in the diagram, CENTRE, the two main cables are both tensioned, and are held by ground anchors, and the diagonal bracing ties are also tensioned by calculated amounts. Thus a truss composed entirely of tension members is formed. As a typical example, a truss spanning 150ft might consist of main cables of 1⅜in diameter ropes, with a pretension of 30 tons in each, and pretension of say 4 tons or less in each of the diagonals, giving a factor of safety of about 2½ with a light roof covering.

The wire ropes are repeatedly loaded and unloaded at the works, until hysteresis effects disappear and purely elastic behaviour is achieved, and the stay locks (which fasten the diagonals) are fixed on while the ropes are under tension. The ropes can then be measured to the exact lengths needed on the site to impart the calculated pretension. In erection, the two main cables are first slung, and then clamped together at the centre; the diagonal ties are then attached and tensioned. A small pull on one of these ties induces a comparatively large tension in the main cables, so the pretensioning is quite a straightforward process. Turnbuckles and strain gauges are employed to supplement or replace the factory loading, if necessary.

The illustration ABOVE shows the ground anchors and roof structure of a supermarket at Orly near Paris; it has a clear span of 141ft, and was completed last month. The illustration BELOW shows temporary exhibition buildings at Le Bourget, which are to be re-erected each year, as if they were tents. There are thirteen spans in the rear and nineteen in the front building, all of 14m; the roof consists, in this case, of plastics panels erected on a jig (as shown in the foreground) which is hoisted up and removed when the panel has been fixed to the lower cables of the four trusses. The system is suitable for long spans, a roof of 500m span being at present in design and lends itself to striking architectural treatment. The direct cost of a roof spanning 15m, not counting the anchorages, is nearly 5s. per square foot.





RIGID CABLE ROOF TRUSS.

each clutch and a corresponding number to an inner-member or hub, the latter being splined to the output shaft. The drums are the clutch driving members, and when the two sets of plates of a particular clutch are forced together hydraulically against the action of the clutch return spring, the clutch drives the output shaft. Through gearing, the clutch drums are arranged to rotate in opposite directions, so that the output shaft is driven in the selected direction according to the clutch engaged. The pedals, which can be seen in the illustration Fig. 5, for operating the shuttle transmission and engine speed, are controlled by the driver's right foot. Depression of the right hand pedal selects forward motion, and the left hand pedal—reverse motion. The central pedal is used for controlling engine speed.

Two models of the M-F 65 tractor (THE ENGINEER, December 9, 1960), have now been introduced into the industrial range. The 65S has a standard transmission whilst the 65R is fitted with the shuttle transmission.

F. TAYLOR AND SONS (MANCHESTER), LTD.

An earth boring machine introduced by F. Taylor and Sons (Manchester), Ltd., Salford, Lancs, is manufactured under licence from the Salem Tool Company of U.S.A., and three different models are to be produced. In pipe laying operations the borer is designed to enable horizontal hole boring without disturbing the surface.

The machine (Fig. 6) comprises a steel main frame carrying a sliding sub-frame propelled by hydraulic rams. Mounted on the sliding frame is a power unit, complete with clutch and four-speed gearbox, a reduction gear, and an auger and auger head. The auger head construction can be varied to suit ground conditions, including all types of compacted earth, clay, gravel, hardcore, sand and soft limestone formations. The drilling rate is stated to be in the region of 30ft per hour under average conditions of packed clay or loam, but where the hole is cased or sleeved the drilling speed can be increased. Casings to protect the hole from collapse are welded section by section as they are assembled on the machine before being hydraulically pressed into the bore. The augers have a standard length of 6ft and matching casings are used, the length being determined by the travel of the sliding carriage which is 8ft. This allows a minimum of 1ft at each end of the casing to couple up the following auger.

In general practice the borer operates in a small trench dug to the depth at which the pipe is to be laid. With the machine placed in the trench and levelled-up the auger head and first auger section are lowered on to the carriage together with the first pipe casing section—if a casing is to be used. The auger is coupled on the drive shaft, and fastened by quick release coupling pins. The machine is then set in motion—turning the auger through reduction gearing from the diesel engine—and pushing the casing or pipe by hydraulic rams. When the pipe and auger are within 1ft of the bore entry the machine is stopped, the auger uncoupled and the machine retracted by reversing the hydraulic rams. Another auger and pipe section are then placed on to the machine, the new auger section connected, and the pipe lined up and welded around the complete seam. The boring and pushing sequences are continued until break-through is achieved, after which the auger can be retracted, section by section, by reversing the boring procedure. For this purpose retractable auger heads are available which automatically collapse when the auger is pulled back through the casing. Alternatively the fixed design of head is removed before the augers are retracted.

The three different models of earth borer being made will accept augers up to 12in, 16in and 24in respectively. Although the largest auger which can be fitted to the biggest model is 24in diameter, holes can be bored up to 48in diameter by using a back reamer attachment. The longest hole yet bored in one operation is 250ft in length, but the manufacturers claim that it will be possible to bore as far as 500ft and even longer borings are possible by carrying out the operation in stages.

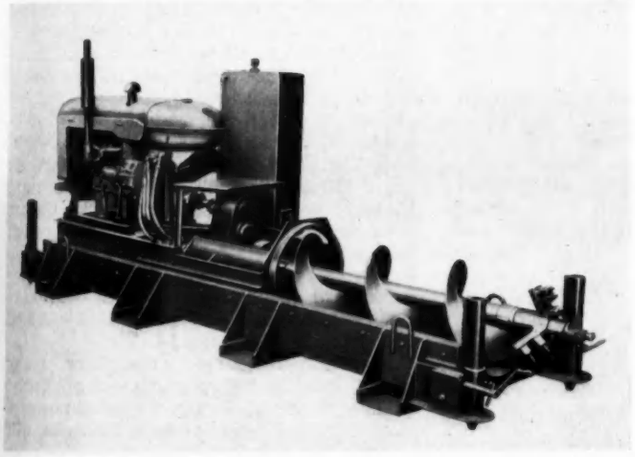


Fig. 6 — The "Taylor Salem" earth boring machine

JOY-SULLIVAN, Ltd.

A new machine of Joy-Sullivan, Ltd., 7, Harley Street, London, W.1, is the "Trac Drill," a self-propelled crawler-track-mounted carrier fitted with a drill of 4½in bore (Fig. 7). The carrier, which was designed for moving deep-hole percussion drills over the roughest terrain and to provide stability and manœuvrability in drilling operations at practically any angle, is power-operated in all its movements. The drill, which is capable of drilling holes up to 4in diameter, 40ft deep, is equipped with a dual rotation device which provides a positive fast method of coupling and uncoupling drill steels and assists normal rotation under adverse drilling conditions. The conventional rifle-bar-actuated reverse rotation is dispensed with and used in its place is a vane air motor, geared to the drill chuck and mounted within the chuck housing. This motor, in providing independent rotation in both directions, reduces wear on couplings, striking bars and other parts during steel changing.

On normal drilling the air motor is uncoupled and conventional rifle-bar-rotation is used. Extra power for forward rotation can be selected as required by engaging the air motor, thus giving good speed in difficult ground and preventing stuck steels.

The firm's new rotary vane portable air compressor exhibited, the "Airvane," has a capacity of 260 cubic feet per minute free air delivered at 100 lb per square inch. The model shown is powered by a Ford diesel engine, but Ruston or Perkins engines can be fitted. In this design the conventional air receiver is dispensed with and its function is covered by a special adaptor housing which incorporates the oil reservoir and air/oil separator.

BLAW KNOX, LTD.

New equipment made by Blaw Knox, Ltd., Rochester, Kent, includes the "AP-100" concrete mixing plant which, incorporating either one or two "Gyramixer" 1 cubic yard pan concrete mixers, is stated to ensure accuracy in meeting required concrete specifications. With two mixers the plant maintains an output of 100 to 120 cubic yards per hour, whilst with one mixer the output is halved. The equipment is essentially an eight-compartment batching plant having 100 cubic yard aggregate storage capacity and including a portable extendible bulk cement storage and weighing unit. The exhibit at Crystal Palace is a typical plant with one mixer, two 30-ton bulk cement silos, and an "Auto-Airflow" ground receiving hopper.

The latest design of this firm's PF-90 "Series B" paver-finisher incorporates a new hydraulically operated folding hopper and a simplified ratchet tamper and screed crowning device. The new folding hopper provides individual control of movement of each hopper side—which assists in maintaining a positive flow of materials on to the individually controlled bar conveyors. This control is of importance when there is uneven

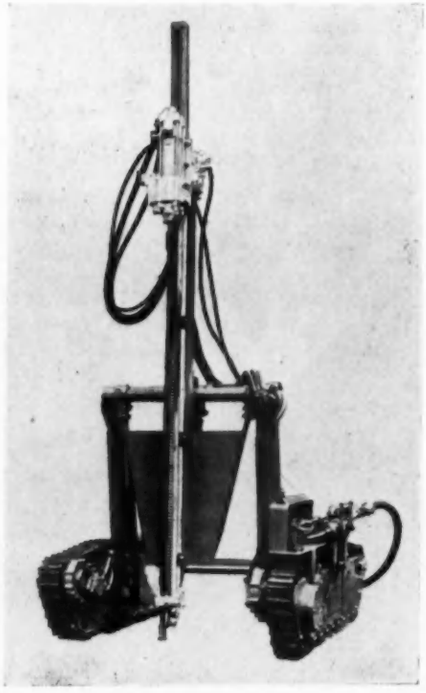


Fig. 7—Self-propelled crawler-track-mounted carrier with dual rotation drill

demand at the screw feed, as when a wedge-shaped mat is being laid.

The "BK-Fifty Ranger" mobile crane excavator incorporates independent power boom hoist and power hook lowering attachments and it is exhibited with a new 50ft tubular jib. The machine as a crane has a capacity of 11½ tons, a jib range from 30ft to 70ft and can operate with a fly extension on jibs of from 30ft to 50ft. It is readily convertible to grabbing crane, pile driver, dragline, face shovel, drag shovel and skimmer. As an excavator the machine has a capacity of ½ cubic yard.

British Crane and Hoist Company, Ltd.

In addition to one of its "Iron Fairy" 6-ton-capacity hydraulically operated mobile cranes, the British Crane and Hoist Company, Ltd., Compton, Berks, is demonstrating the new sewer dredging rig. A dredging equipment includes two mobile winches and a set of shear legs as shown in Fig. 8. To set up the equipment for dredging a winch is positioned by the manhole at either end of the section to be dredged, and a light hemp line floated through the sewer from the return winch at the head of the flow to the dredging winch manhole. Attached to this line is the wire rope of the return winch coupled to the return pull ring on the mizer or badger.

The pull bale at the mouth of the badger or mizer is attached to the wire rope of the dredging winch and horizontal lead diverter sheaves and struts are positioned across the manhole at either end of the section. The haulage winch is then operated, and the return winch is used on the light line to pull the badger or mizer back to the head of the flow to continue the cycle of dredging pass and return. Since each winch is of the same direct line load capacity and speed, the two winches can be readily interchanged for use as haulage or return winches.

Marshall Organisation

A new road roller with hydrostatic transmission is shown with the rollers and crawler tractors on the stand of Marshall Sons and Co., Ltd., and John Fowler and Co. (Leeds), Ltd., member firms of the Marshall Organisation of Gainsborough. The new three-wheeled roller, to be seen in Fig. 9, also has a system of ballasting whereby its weight can be varied between 9 tons and 16 tons. Alternative power units can be provided—either a water-cooled Perkins four-cylinder engine developing 50 b.h.p. at 1750 r.p.m., or a three-cylinder, air-cooled Ruston engine developing 46 h.p. at 1750 r.p.m

The "Dowmatic" hydrostatic drive between the engine and the change-speed gearbox consists of a variable-delivery tilting head piston pump driving a fixed-displacement motor. Variation of the pump angle controls the speed and direction of rotation of the hydraulic motor. This transmission gives steplessly variable road speeds up to 5 m.p.h. forward and reverse, and during normal rolling duties the engine is kept running at its optimum fuel consumption speed. The final drive to each rear roll from the hydraulic motor is through a worm reduction gear unit and differential to four pinions engaging internal gear rings on the rolls. Power-operated hydraulic steering equipment gives control over a total of 80 deg. lock and band brakes operate with a servo action directly on the driving rings of the hind rolls.

The main frame of welded steel construction incorporates the ballast weight compartment, water tank and a rear towing attachment. Ten separate 10 cwt cast iron ballast weights which can be placed in the central compartment of the machine enable its net weight to be increased by 5 tons. To vary the front and rear roll pressures weights in 1 ton units can be placed in the front or rear of the ballast compartment. The welded steel rolls have plugs through which they can be filled with water ballast and removable plates for filling with sand ballast if required. A two-tine hydraulic scarifier available for this roller is carried on a 4½in diameter steel shaft behind the right-hand rear roll. It has variable depth control and can be operated from either side of the roller or from the driver's seat.

A "Challenger 33" crawler tractor exhibited is equipped with a Marshall angle-dozer incorporating sealed hydraulic power rack which is located within the protecting nose-piece of the tractor. Hydraulic power is supplied by a balanced vane pump through a four positional open-centre valve giving lift, hold, dig and float positions. The float position is held by a detent and the valve is spring centred to hold from lift and dig. The pump and control valve are enclosed in the tank, which is a ribbed steel casting fully pressurised. Control is exercised by a short conveniently placed lever which is connected to the control valve through self-adjusting ball joint linkage.

Fig. 10—"Implematic" tractor with rear-end digger in use; the tractor is also fitted with a front-end loader

David Brown Construction Equipment, Ltd.

The industrial wheeled and crawler tractors with ancillary equipment made by David Brown Construction Equipment, Ltd., Melthun, Huddersfield, includes an "Implematic" tractor fitted for the first time with a "Shawnee" rear digger as well as a front-end loader. The digger (Fig. 10) is capable of loading to a height of 8ft 10½in, digging to a depth of 11ft 3in, and has a maximum reach of 11ft 3in. Fully hydraulic in operation, the machine will swing through an arc of 180 deg. and will dig in line or at right angles to the tractor. A range of six bucket sizes from 12in to 36in is availale, each having replaceable teeth and reversible side cutters. The front-end loader has a ¾ cubic yard capacity bucket with controlled tip. A maximum lift of 1700 lb is specified and discharge height is up to 9ft.

Representative of the "Taskmaster" range of industrial haulage tractors is the "Turbo Shunter," a 42·5 b.h.p. diesel-powered machine fitted with shunting plates at the

Fig. 8—Sewer dredging rig at the haulage end

Fig. 9—Road roller with hydrostatic transmission and hydraulic scarifier

front and rear. For towing purposes, a five-position rear hitch is fitted, together with a single front jaw.

Of three crawler machines to be exhibited, two are based on the six-cylinder, 50 h.p. model, one is fitted with a 1 cubic foot capacity bucket, and on the second are mounted a hydraulic angle-dozer and a rear-mounted ripper.

Babcock and Wilcox Ltd.

Examples of horizontal saddle-jib Babcock-Weitz tower cranes are shown by Babcock and Wilcox, Ltd. One of these machines is a type "G 15 HV-A," a rail-mounted crane, with a jib radius of 66ft and a lifting height of 43ft. It has a two-speed main winch and is fitted with a cable winder unit. This design is also available with jib radii of 56ft and 80ft. When these machines are fully mobile additional tower sections can be used to increase the lifting height to 95ft, and when they are anchored to a building the towers can be increased to a height of 148ft. Lifting capacities vary from 40 cwt at 25ft jib radius to 11 cwt at maximum jib radius of 75ft.

The type "G 60 HV-A" telescopic, rail-mounted tower crane shown has a maximum jib radius of 99ft, and a lifting height of 72ft. This crane has twin saddles which are linked in tandem and capable of a maximum load of 6 tons ; it is fitted with a two-speed main winch. The machine is also available with jib radii of 59ft, 85ft and 99ft. Arranged for mobile working the crane can travel with its load at a height of up to 144ft under the hook. When anchored to a building, the crane height can be increased to 400ft and progressive increases in height can be made as the building grows.

Future of Civil Engineering Research

In his Unwin Memorial Lecture presented before the Institution of Civil Engineers on May 30, *Professor Baker* (*who was the recipient of a knighthood in the Birthday Honours List*) *presented a historical account of the work of the research committee of the Institution of Civil Engineers, established in* 1935, *introducing that account with some references to researches carried out by individual engineers at the end of the eighteenth century and during the nineteenth century. The lecture ended by giving some thought to the future and it is that section of the lecture which we print below.*

Formation of Civil Engineering Research Council

WHILE this record of work carried out largely by voluntary effort is striking enough, it has long been clear to the members of the research committee that throughout its history the one big difficulty has been that of finance. Generous support has been given from time to time by the Department of Scientific and Industrial Research and on several occasions by both sides of the industry but it has not always been so and the committee has then been unable to exert that influence on the researches which independent financial provision makes possible. Furthermore, the D.S.I.R. has let it be known that continued financial support could not be hoped for unless the industry itself was willing to do more than state the problem and collate the conclusions of research. Following correspondence with the Federation of Civil Engineering Contractors and the Association of Consulting Engineers, a few representative contractors and consulting engineers were invited by the president to meetings to discuss what would be the best way of tackling the financial problem.

The continuation and expansion of civil engineering research is of more importance to the nation now than at any time in the past, particularly in the export field on which the economic strength and standards of living of the country may be said to depend. The Advisory Council on Scientific Policy, in their last annual report, mention the serious deficiency in research over the whole field of civil engineering. The work carried out by many contractors in their own laboratories, and by consulting engineers was recognised in that report ; but it was also realised that there was need for research which, while not perhaps of any immediate or direct benefit to individual firms, should, nevertheless, be undertaken in the national interest. Further, it is particularly important that the results of research should be published and should be applied in practice as quickly as possible, and it was agreed that this could best be done through an independdent co-ordinating body such as the Institution of Civil Engineers and its expert committees.

As a result of these discussions and of devoted work by a few members, a Civil Engineering Research Council was established on November 22, 1960. A draft constitution was submitted to the D.S.I.R. who have recognised the Council as an organisation eligible to receive and administer grants from the Department. These will broadly match any sum contributed by industry provided the fund reaches an effective total. D.S.I.R. will be represented on the Council, together with the Institution, the Federation of Civil Engineering Contractors and the Association of Consulting Engineers.

Co-ordination of Research

The Institution has already had much experience in co-ordinating research. A new and essential feature of the Research Council is that it undertakes to provide adequate funds for research on the scale required in the national interest. Only thus can civil engineering be placed on an equal footing with other major industries and enabled not only to keep abreast of developments but to initiate them. Consulting engineers and contractors had up to a few weeks ago offered contributions totalling £20,000 per annum. This is the minimum necessary to allow the Council to start its work. Even the existing researches are estimated to need £250,000 to complete them and so more support is needed if the work is to proceed on a proper scale. Whatever additional support is forthcoming we are indeed faced with new opportunities and a new challenge.

Organisation

Details of organisation have not yet been worked out and it is not my intention to discuss them, but experience with other research associations leads me to believe that there will be two central bodies, a council and a research committee. The duties of the former will be to raise and allocate funds and, in collaboration with the research committee, to decide priorities. The research committee's main function will be to organise and supervise the research and to consider how, by publication, or otherwise, it can be presented for the benefit of the profession and of the community ; it will almost certainly appoint sub-committees to deal individually with the various projects.

The membership of the two central bodies will be drawn from all branches of the profession, consulting engineers, firms of contractors, industry, Civil Service Departments including, of course, D.S.I.R. and mechanical scientists. They will all be men of standing and experience and, though heavy calls on their time will undoubtedly be made by the Research Council, they will all have primary responsibilities elsewhere and cannot alone run the affairs of the central bodies. They must have a permanent full-time staff. It is, in fact, already proposed to appoint a research secretary who will be responsible for the administration of the research activities. In my opinion, and I have been intimately concerned in the establishment of other research associations, this officer will need almost from the beginning at least four other highly qualified mechanical scientists to assist him even though, as I believe to be wise, we maintain the policy of not setting up our own independent laboratories. We might glance for a moment at some of the duties that must be performed by this team of full time workers. They must prepare briefs for the information of the central bodies, first so that priorities can be decided and later so that the destinations of the investigations (where, that is, they are to be carried out) can be decided.

Subjects for Research

Subjects of research are of many kinds and can come from many sources. There are those proposed by universities and other research organisations who are convinced of their importance ; they come, cut and dried, ready to be started but held up by lack of funds. There are those proposed by various branches of industry, by consulting engineers and by the Institution's divisional boards ; these are seldom cut and dried but are usually presented as difficulties met with in practice. They may well be amenable to research but they may be more fruitfully dealt with by a questionnaire or by a search of the literature. There are, finally, a most important group, those which should be but are not proposed by anyone. I am not trying to be facetious in saying this. It has happened in the past, and may well happen again, that some branch of industry is quite contentedly using well tried methods which could be radically improved, to the great advantage of the industry itself and of the community, by appropriate research. In this connection it may be said that while, because of the nature of the work we do in civil engineering, "the inventive sector" is narrow yet the emergence of big and important innovations is not frequent enough. I should like to see a survey of the "state of the art" made by some gifted group, led, perhaps, by our research secretary to reveal what sectors could be opened up. This would almost certainly lead to some long-term and some speculative work, but we

should be prepared to invest in this since the prizes should be large. What is more, activity of this kind would add to the glamour of civil engineering research and we are sadly deficient in this respect.

Work of the Research Secretary

The research secretary will not have completed his first task if he presents nothing more than a list of the possible researches collected from the sources mentioned above. He must, remembering the total resources available, help the central bodies to decide on priorities by preparing briefs. To do this he may even have to make an economic and statistical investigation of the work actually undertaken by the civil engineering industry. I would, of course, be the last to suggest that research effort should be allocated proportionately to the turnover in industry on the processes or materials which that research is expected to help, but a statistical investigation would at least allow the Council to make its decisions on the basis of fact and not merely because one member or a sub-committee was particularly vigorous in pressing for work which might or might not be of national importance.

Once the items have been put in an order of priority the research secretary faces the really difficult part of his duties. He must find the best organisation, whether it is a Government station, a research association or an academic institution, to undertake the work. The costs, speed of execution and ability vary considerably from one to another and the secretary must have a sufficient standing and flair to enable him to advise the central bodies as to the most satisfactory arrangement to make. Once the projects have all been found homes he must watch their progress. In fact, knowing research workers as I do, he must keep their eye on the ball within reason and see that they make their reports by the contract dates.

I have by no means exhausted the tally of duties which the research secretary must carry out, but I believe I have said enough to show that he must be a man of considerable ability and of sufficient standing in research to talk as an equal with those in other organisations who are to carry out our researches. He must, in fact, have the status of a director of research and he must from the start be supported by an adequate staff.

Research Workers

However able the permanent staff, success ultimately depends on obtaining sufficient men of the right calibre to carry out the actual researches. Here we have no grounds for over optimism. This, as I see it, is largely due to the attitude to research in many branches of engineering. Though we are continually told of the vital importance of engineering research it still seems to be looked upon, in some quite influential quarters, as if it were a hobby which a man embarks upon because he is incapable of doing real work and which should not be encouraged too much, certainly not to the point where competitive salaries are paid. In fact, productive engineering research is extremely demanding. To carry it out successfully we must have men of high intellectual ability, the short supply of which over the whole field of engineering is a national problem. It calls for a practical outlook and more than the usual share of determination. It is not enough to conceive a theory, however original and potentially valuable. The theory must be completely tested and that is why a practical flair is essential. Up to this point, where the scientific aspect of the problem has been thoroughly explored, the mechanical scientist's research differs little from that of the pure scientist, but he cannot rest there since his results would be of little use to the practising engineer. To complete the job, the mechanical scientist must embark on what, in my experience, is the most intellectually difficult part of the exercise. He must turn the complete scientific solution into a simple yet rational form. The derivation of this is infinitely more difficult than the development of any single *ad hoc* design. In spite of its difficulty this, so called, development work brings little or no scientific reward, only a feeling of immense satisfaction.

In this time of shortage we cannot depend alone on those ingenuous enough to work only for their interest in the job, we must use every means at our command to attract other able men. The Research Council must use what funds it has available to pay to assistants salaries at least as high as those ruling in other engineering posts, and the industry must see that those who, by their devoted efforts, add significantly to its prosperity do not go virtually unrewarded.

This country is often criticised for its backwardness in some technological fields. If the criticism is justified then I believe it is because of our archaic attitude to research. Other countries have their various, but all more successful, methods of dealing with the point I have raised. We should learn from them. What we have done in the past, to rely so much on near-voluntary work, may have been satisfactory in the easy days that are gone, but now in this period of expansion we must offer solid inducements if we are to attract our quota of outstanding men.

I hope you do not feel that some of my remarks are inappropriate in a memorial lecture. If so, I am sorry, but from what I know of Unwin and his work I feel that he would have had great sympathy with much that I have said. While the earlier part of the lecture will, I hope, have made it clear that I am lost in admiration for the volume and much of the quality of the work that has been done in the past quarter of a century, we are faced now with more urgent and more exacting tasks. We are in fact entering a new and most exciting era in civil engineering research which will have a profound influence on our profession and on the prosperity of this country. For this we need a different approach to research and I make no apology for putting my views to you in plain language.

London's Traffic Survey

THE following note is taken from the report of the Roads Committee in the London County Council's agenda paper for the Council meeting of June 20 :

The appointed consultants, Messrs. Freeman, Fox and Partners, have submitted their report on the London traffic survey, which has been carefully considered by the Council's officers, and by a small control team, drawn from the Council, the Ministry of Transport, and the road research laboratory of the Department of Scientific and Industrial Research, and the Metropolitan Boroughs' Standing Joint Committee, working under the general directions of the Ministry's London road planning group. In all, three different schemes were considered. One, costing some £510,000, allowed for obtaining rather more information than we thought necessary from people who do not own cars, and was also designed to obtain additional information which is either already available or can be obtained more cheaply by other means. Another scheme was somewhat cheaper, but was in such a form that it would have been much more expensive later to obtain estimates of likely traffic flows in the future. We are confident that the third scheme, costing about £425,000, will obtain all the information we need at the lowest possible cost.

We have decided that the survey should be carried out by the appointed consultants who, through their American associates, Engineering Service Corporation of Los Angeles, California, incorporating Messrs. Wilbur Smith and Associates, traffic engineering specialists of New Haven, Connecticut, have considerable experience of American technique and information. It will cover broadly the area within the Green Belt. This is essential, because a large proportion of the traffic within the county does not originate there. The principal object of the survey is basically quite simple. It is to ascertain what journeys are made by road within the area ; where people start from and where they go to. For this purpose, the area surveyed will be divided into 900 zones, and traffic movements between these will be deduced. This origin and destination survey is not concerned with the route at present used, which may not necessarily be a good one, although it may be the best available. The information obtained is to enable a road pattern to be planned which will enable people to make the journeys they wish with the minimum of expense and inconvenience, both to themselves and to the community at large. It will be appreciated that an origin and destination survey by itself would enable only present requirements to be ascertained. But a road takes many years to plan and build and if it is to be adequate when it is opened, and for a long time after, then obviously many other factors, and not just present requirements, must be taken into account. Apart from the obvious effect of a growth in the use of private transport and the provision of parking facilities, there are many other influences much less easy to estimate, such as population movements, changes in land use, opening of new railways or improvement of public transport services, to mention but a few. The traffic study, then, will obtain a lot of information in addition to the origin and destination survey, but this will remain the foundation.

The information will be obtained principally by home interviews, supplemented by road-side interviews, a commercial-vehicle survey, traffic counts and journey time analysis. In addition, information will be obtained from other sources on use of public transport and taxis. The detailed arrangements will be supervised by the control team. For the home interviews, a 2 per cent sample of households will be interviewed—50,000 in all. Of these 50,000 households, nine out of ten will be households with cars. Particulars will be sought of all journeys made by all members of the household on the previous day. By careful arrangement of the interviews it will be possible to find out what variations there are between different days of the week and different times of the year. A lot of information will be obtained on all forms of travel, and the small sample of households without cars has been included to provide a check against the information obtained from car-owning households on travel other than by car. This method has been chosen in preference to the standard American method of taking a random sample of households, because car-ownership in this country has not reached a high enough level to provide a sufficiently accurate sample by this means unless the random sample is very large. The interviewers will be recruited, trained and organised by the consultants.

Roadside interviews of about one driver in ten will be conducted, it is hoped with the aid of the police, on all roads crossing a cordon on or near the boundary of the survey area and at check points in the area. About half of the stations will operate for twenty-four hours in order to get information on night travel. This should yield about 150,000 interviews. There will be no advance notification of where the interview stations will operate as that might introduce statistical bias. There will also be separate interviews of drivers of a 20 per cent sample of commercial vehicles. Traffic counts will be made by automatic recorders at a number of points and times will be obtained of peak-hour and off-peak journeys made in each direction over a selected network of principal streets.

The information so collected will be analysed by the Council's computer. The fully analysed results should be available in about two years' time, but interim information will be continuously received during this period and could be available for analysis for particular road proposals. At this stage, no arrangements have been made to project the information to make estimates for ten or twenty years ahead. This cannot be done until the current information has been collected, analysed and presented. There are various ways of making the projection, and during the intervening two years we shall look into this point very carefully in order to ascertain the best method to suit London's problems. The present estimate therefore excludes the cost of the actual projection itself. This is not only the first survey of such size in this country, it is the largest ever undertaken in the world, covering 900 square miles, with a population of nearly 9,000,000, 1100 miles of trunk and class I roads, and a similar mileage of class II and class III roads. The largest surveys up to the present have been in Detroit and Chicago, but the areas and populations surveyed there were considerably smaller than the area now to be surveyed, and in any case conditions in American cities are not the same as here.

When the survey is completed it will be possible to establish the nature and volume of the complete traffic flows on the main motorway and trunk routes leading into London, to establish the need for main crossing or ring roads and other new and improved roads within the survey area and to enable their capacity and best location to be decided. The consultants conducting the survey will not make any detailed recommendations themselves on the design and location of any new roads, as many other factors have to be taken into account besides the information on traffic obtained from the survey. The better planning of London's road programme is the principal purpose of the survey, but it will also supply the Council with means of comprehensive analysis of travel facts by which it will be possible to maintain an up-to-date picture of London traffic. The The statistical data will afford a wealth of opportunity for research into the basic characteristics of urban travel. This realm of investigation has barely been broached anywhere and certainly not in so vast a metropolis as here. Its potential value, for instance, in guiding the orderly and efficient planning of transport and terminal facilities, is far-reaching.

The carrying out of the survey is certain to cause some trouble and inconvenience to members of the public. We should like through this report to appeal for their co-operation and forbearance ; and we have every hope that the time they may spend in giving the information asked for will be repaid later by many hours saved.

The agreement with the consultants will provide for the payment to them of their direct costs in carrying out the survey, together with fixed fee. Arrangements will be made to keep the direct costs under continuous review as the survey proceeds. The present total estimated cost is £425,000.

Electric Train Accidents and Failures

A SECOND interim report* has been published on the accidents and failures in multiple-unit a.c. electric trains of the Scottish and Eastern Regions of British Railways. The Inspecting Officer, Brigadier C. A. Langley, says in his report that good progress has been made with modification and testing of the Glasgow suburban stock, and since the first reconstructed train was tested on March 21 to 23, the number of units in Scotland has been increasing at an average rate of five a week. On May 3 thirty-two units were available for trial running and driver training. It is intended that the first reconstructed train, on which tests are being carried out, will be run for some 20,000 miles, and all others for about 2000 miles each before being introduced into the public service. The first report on the Scottish train failures was summarised in our January 20 issue, page 93.

Dealing with the Eastern Region train failures, the present report shows that only minor difficulties occurred during the trial running of these trains on the 25kV Colchester-Clacton line, where all of them were commissioned and the voltage changeover equipment tested. There were some difficulties with rectifiers and battery chargers which persisted during the next stage of trial running on parts of the North East London suburban lines on which the units were eventually to be used. This began in May, 1960, and was gradually extended as the overhead equipment was completed. During this phase a defect in the clamping of the transformer windings was discovered and corrected on all units before the introduction to public service. Public services began with a week's running in steam timings from November 14 to 20, 1960, when forty units were in operation. The full public service on the fast electric timings was introduced on November 21 and almost immediately the service was seriously affected by a breakdown of traction motors, whilst rectifier and battery charger failures continued.

Between December 12, when the service was reduced, and May 3 which is the end of the period reviewed in this report, there was a satisfactory improvement in the failure rate of motors and battery chargers as modifications were introduced and the report gives particulars of the number of failures of main components during the significant periods. These trains have run some 800,000 miles in public service.

Early this year the contractor, The General Electric Company, Ltd., decided to equip a train as a mobile laboratory to measure all the phenomena involved. The fundamental cause of the troubles is shown to be over-voltages higher than those which the traction motor fields and the battery chargers could withstand, and a weakness in the design of the rectifier anodes and cooling system. The failures of traction motors have been virtually eliminated by changing the point at which the secondary circuit was earthed, but this has involved the installation, which is now in progress, of additional surge suppression equipment for other parts of the secondary circuit. It has not been found possible to suppress these surges to a value which the original selenium rectifiers of the battery chargers could withstand, and these are being replaced by others capable of withstanding a much higher voltage. The main rectifiers are being modified to overcome the weakness mentioned above and the cooling arrangements are being altered to modify the distribution of temperature in the rectifier.

The transformers did not give any significant trouble until one transformer failed in service at the end of April. This and four other transformers have been examined and another has been subjected to short circuit tests. In the contractor's opinion the failure was an isolated case and although certain of the internal connections need strengthening, they consider they are fit and safe to remain in service, but the Commission is having further tests made before deciding whether more extensive modifications are necessary.

In his conclusions Brigadier Langley summarises the results of the investigations and reports that up to the end of April when a transformer failed in service, the main causes of the breakdowns were :

(*a*) The failure of traction motors arising from short circuits to earth in the motor field circuit.

(*b*) The breakdown of mercury arc rectifiers, principally on account of loss of vacuum.

(*c*) The failure of battery chargers resulting in the exhaustion of the 110 volt battery which supplies power for the lighting, heating and control circuits, as well as for the auxiliary air compressor.

The breakdown of the motors and of some of the battery chargers was primarily the result of transient over-voltages of high magnitude developed by the opening of the air-blast circuit-breaker when the trains were operating on the 6·25kV sections of the line. It was thought that the main rectifier troubles sprang from the same source, but eventually it was discovered that the cause was metallurgical and thermal rather than electrical. Brigadier Langley points out that the effect of these over-voltages on the secondary and tertiary circuits are four times greater when operating on the 6·25kV sections than on the 25kV sections of the line. This is because the primary over-voltages are largely determined by the inherent characteristics of the air-blast circuit-breaker and are approximately the same when operating on either line voltage, whereas the step-down ratio to the secondary winding is four times greater on 25kV than it is on 6·25kV.

The most serious over-voltages were generated when the circuit-breaker opened with the d.c. motor current changed to a pulsating half-wave current by a temporary loss of excitation on some of the rectifiers. This phenomenon occurs when loss of contact between the pantograph and the overhead wire (pantograph " bounce ") happens so frequently that some of the rectifiers are no longer able to re-ignite and so " lock out." The worst place was in Clapton tunnel where as many as fourteen consecutive " bounces " were recorded. Frequent loss of contact was also recorded when passing through Clapton neutral section.

The G.E.C. is now fully engaged in applying the agreed modifications but it is unlikely that all G.E.C. units will be completely modified before the end of the summer, especially in view of the transformer difficulties.

In conclusion, Brigadier Langley points out that the failures in the Eastern Region arose primarily on account of the onerous conditions set up when running on the 6·25kV section of the dual-voltage system and he recommends that the research initiated by this investigation be extended to cover all the high voltage a.c. lines.

In the first place problems of changeover from one voltage to another require further study. Secondly, the operation of the air-blast circuit-breaker should be examined to see whether the effect of rapid " chopping " can be reduced when operating on 6·25kV. Thirdly, the cause of pantograph " bounce " should be examined further, including the relationship between the moving pantograph and the overhead wire, which depends not only on the alignment and level of the wire but also on the reaction of the vehicle, influenced as it is by the condition of the track and its own springing characteristics.

Brigadier Langley also points out that these investigations have shown that faults in minor pieces of equipment and the premature operation of safety devices may cause troubles which lead to breakdowns in service. The need for simplification is apparent and he recommends that this question be pursued vigorously. A full report on all the factors affecting these failures and other relevant matters will be presented later.

* Second interim report on the accidents and failures which occurred in multiple-unit electric trains in the Scottish and Eastern Regions, British Railways (H.M.S.O. Price 1s 9d.).

Hydromechanics Research

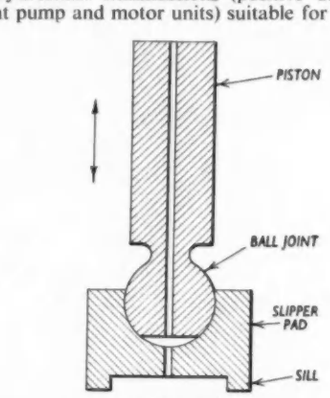
LAST week the British Hydromechanics Research Association had its annual open days at its laboratory at Harlow. About thirty models or demonstrations of various kinds were to be seen, thus well demonstrating the interesting and varied researches which the Association has in progress. The use of air models for investigation of hydraulic problems was again a prominent feature of the work in progress. Air models have been used to investigate certain problems in the behaviour of centrifugal pumps (see also THE ENGINEER, July 24, 1959, page 26), the behaviour of the turbine intakes at the Kariba hydro-electric scheme and also the Ffestiniog pumped-storage scheme in Wales. A number of studies of reservoir spillways and stilling basins have also been carried out, the most recent one, which is now in progress, being an investigation of the design of these works at the Sasumua dam near Nairobi ; a one-thirtieth scale model has been constructed, and will be used to study the junction of the spillway and a natural watercourse, where a flow of 16,000 cusecs must be allowed for and where the site conditions are adverse. Two examples are given to illustrate the Association's work.

Cooling Water Intakes at Sizewell Nuclear Power Station.—The difficulties of siting and constructing off-shore intakes and outfalls for the cooling water system of large power stations are well known. This research aimed at attaining the best hydraulic performance for the intake and outfall structures, at the nuclear power station at Sizewell, Suffolk, where constructional work has just started. It is an interesting example of the use of air models, in conjunction with a final study with a water model.

Two intake towers, side by side, leading to a common tunnel were proposed. This general configuration was shown to be satisfactory from the hydraulic standpoint, but refinements in the shape of the intake and outfall conduits were suggested, and the final design is shown in the diagram herewith. There are two outfall towers leading from a common outfall tunnel, and the design in that case is generally similar to the intake. Apart from a general appraisal of the hydraulic aspects of the design, this study has reduced the head losses in the Sizewell intake from about 3ft to about 1ft to 6in. This reduction does not result in a very large saving in terms of pumping horsepower, but is, we understand, important in terms of saving of capital cost in constructing the sump, &c., of the pump house, due to reduction of excavation and depth of the sump.

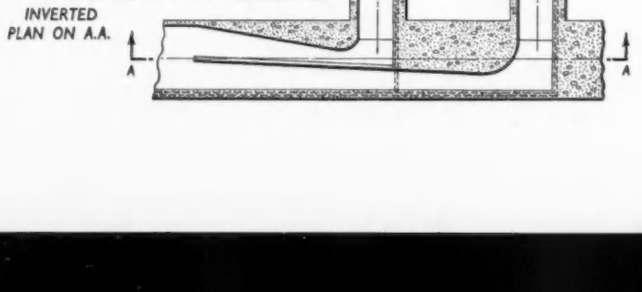
In investigating the design a small-scale air model was first used for a general appraisal. An interesting point emerged at this stage, since the configuration was very similar to that encountered in another problem which had been studied by the Association, namely that of air flow in the upcast shaft of a colliery. Just as for the air and water models, the criterion of comparison between air and water closed-conduit systems is the Reynolds number, so the results of the colliery investigation were of use. This led to the use of flattened cross-sectional shape at the bend at the base of each tower, and the use of the long baffle where the two flows merge, as shown in the sketch. This general shape was tried on the small air model, but refined on a larger air model. Finally, a water model reproducing the tidal surface was used (*a*) to confirm the air model results, and (*b*) to examine the effects of tidal flow and levels on the flow and head loss in the intakes, and the possibilities of the formation of air-entraining vortices.

Hydrostatic Thrust Bearings.—An analysis of the power loss in axial piston pumps and motors shows that a significant proportion of this loss is due to the need for thrust bearings. While conventional ball or roller bearings have low friction characteristics they are severely limited in load and speed, particularly under eccentric loading conditions. The operating characteristics of an alternative form of thrust bearing have recently been studied by the Association since it has been concerned with the design and testing of hydrostatic transmissions (positive displacement pump and motor units) suitable for use in private motor cars. As a result the potentialities of a type of hydrostatic bearing for use in axial piston machines are now being studied.



Sketch of hydrostatic thrust bearing

Although hydrostatic thrust bearings for use with axially loaded shafts have been used for a considerable period of time, very little published information is available relating to their use on pump or motor pistons where the pads rotate around a swashplate rather than the axis of the piston itself, as shown in the sketch. Work is now being done to obtain design data for such conditions. The analysis of slipper pad designs under static conditions has been verified by experimental results and an apparatus is now being used to measure leakage, friction torque and fluid film thickness under dynamic conditions. In addition the behaviour of a slipper pad in relation to its spherical ball joint is also being investigated. This is of importance since when a slipper pad is tilted by an external force, the oil pressure distribution under the annular sill changes, and produces a righting moment. Measurements of this inherent righting moment have been made, and an apparatus for measuring the friction at the ball joint will shortly be in use.



Cooling water intakes for Sizewell power station

Major Motorway Contracts

DETAILS have been given by the Ministry of Transport of further contracts which have recently been let on two of the major motorway schemes in the road programme. Large-scale works on the M2 (Medway Motorway) and M6 (Birmingham–Preston Motorway) are included.

The M2, which will be 26 miles in length and will by-pass Strood, Rochester, Chatham, Gillingham, Rainham, Newington, Sittingbourne and Faversham, is due for completion in the spring of 1963. Work is already in progress on the £2·3 million Medway Bridge (See THE ENGINEER, June 24, 1960, page 1076) which forms part of the motorway. The roadworks will be constructed under three separate contracts, amounting in all to just over £11,500,000, as follows :

Section 1 (west of the Medway Bridge for about 2 miles) to a consortium of J. L. Keir and Co., Ltd., Christiani and Neilsen, Ltd., and Sydney Green and Sons (Contractors), Ltd. —£1,006,408 ; Section 2 (Medway Bridge–Stockbury, nearly 12 miles) to G. Wimpey and Co., Ltd.—£5,954,183 ; Section 3 (Stockbury–Brenley Corner) to John Laing Construction, Ltd.—£4,734,665.

The new motorway will leave the London–Canterbury–Dover trunk road (A2) near Strood, west of Rochester, and rejoin the A2 near Brenley Corner, east of Faversham, where it will link with the A299 route to the North Kent coast and the Isle of Thanet. It will be built to dual two-lane carriageway standards, with 10ft wide hard shoulders and full grade separation throughout. There will be two-level junctions at each end of the motorway, and at the intermediate junctions with A228 east of Cuxton, A229 south of Chatham, the projected link road between the motorway near Bredhurst and the A2, the A249 near Stockbury, and the A251 south of Faversham.

Apart from the Medway Bridge and its approaches, there will be sixty-one bridges to build, including three large pre-stressed concrete viaducts over the Stockbury, Bottom Pond and Mount Lane valleys, with spans of 855ft, 375ft, and 480ft respectively. The largest viaduct, that across the Stockbury Valley along which runs the Maidstone–Sittingbourne Road (A249) will be nearly 80ft above the ground. The motorway has been designed by Messrs. Freeman Fox and Partners, acting as consulting engineers to the Ministry of Transport, in association with Mr. R. F. Earley.

The final contract for the construction of the 78-mile Birmingham–Preston Motorway (M6) for the 9½ miles in South Cheshire between the Staffordshire boundary and Holmes Chapel has been let to Sir Lindsay Parkinson and Co., Ltd., in the sum of £5,892,765. The work is to be completed within twenty-five months. The route of this section of the motorway runs northwards from the Staffordshire boundary near Barthomley, passing to the east of Crewe and Sandbach, to a point on A54 between Holmes Chapel and Middlewich, where it connects with the section in North Cheshire for which the contract was let last month (see THE ENGINEER, February 10, 1961, page 215). The construction of twenty-two bridges will be necessary in addition to the railway bridge at Sandersons Brook, now almost completed, which is being built by the British Transport Commission.

The motorway will have dual three-lane carriageways, each with a 10ft-wide hard shoulder and separated by a 15ft-wide central reserve. At the Staffordshire–Cheshire boundary there will be a junction with a new trunk road which it is proposed to build between Talke and Balterly Heath. There will be other junctions, with A534 near Sandbach and with A54 west of Holmes Chapel. The consulting engineers are Messrs. Scott and Wilson, Kirkpatrick and Partners.

SHORTER REPORTS

Electronics and the I.E.E.

THE Council of the Institution of Electrical Engineers has become increasingly conscious that the high proportion of its learned society activities which is devoted to the science, development and application of electronics is not as widely recognised as it might be. The representation of electronics interests on the Council and the main Committees of the Council, as well as the regulations governing the admission of electronics engineers and others to membership have therefore been examined, and at a meeting on May 18, 1961, a resolution on this subject was passed.

It was resolved that steps should be taken to ensure, as far as practicable, equal representation on the Council and its committees of the interests generally identified as "electronics" and "power"; and that examination regulations and training syllabuses should be reviewed to ensure that they are appropriate for those (particularly electronics engineers) not adequately provided for under the present regulations. The Institution states that power and electronics interests will be equal in the Council elected for the next session, to take office on October 1, and it remains to maintain the balance in future, the same aim being followed in the selection of committees. Changes have already been made in the acceptable qualifications for Graduate membership, mainly affecting those who have come into electrical engineering from physics and mathematics. In addition, the syllabuses of the examination proper are now undergoing a detailed review.

Plastic Coated Steel Tube

A RANGE of steel tube coated externally with polythene is now being produced by Carter Brothers (Billingshurst), Ltd., and marketed under the name "Plasticlad" by the Stamford Engineering Company, Ltd., 45, Parliament Street, London, S.W.1. The range is that specified by B.S.S.1387, which covers internal diameters from ¼in to 6in inclusive, light, medium and heavy grades according to wall thickness, and in black or galvanized finish. The tube is first chemically treated to assist adhesion between the metal and plastic surface, and the polythene is then extruded over the tube. Quality control is applied to the whole manufacturing process, with chemical and mechanical checks at each stage, and the product is given a leakage test with a spark detector for coating continuity.

The coated tube has a tough external finish which is resistant both to corrosion and to damage caused by transport and handling. It is suitable for all situations where the strength of steel and the inert qualities of polythene are desirable. It can also be used for applications where the permeability of polythene to certain gases makes the use of the plain plastic tube unsuitable. A range of polythene coated fittings is also available, together with a patented polythene sleeve which is used for jointing purposes. Lengths of tube and fittings are joined by screwing in the normal way, and the polythene sleeve is fitted to preserve the continuity of the coating throughout.

[Reply Card No. 1047]

Metal Strip Coating Plant

A LICENCE has been acquired by Henry Simon, Ltd., Stockport, Cheshire, for the manufacture and marketing in Europe of a range of "Waldron" metal strip coating plants to the designs of the Midland-Ross Corp. of the United States. These plants are used for the application of paint, vinyls, enamel and other protective and decorative finishes to steel and aluminium coil. The plants are built in a number of sizes to handle strip up to 66in wide in thicknesses ranging up to 16 gauge and apply coatings from 1mm to 100mm thick on one or both sides. The process is continuous and, according to the coating applied and thickness of strip, production speeds up to 200ft per minute can be attained.

In a typical plant the strip is drawn off an uncoiler at the feed end and passes through a shearing and a stapling station into a looping accumulator. The shear trims the ends of the coils square and the stapling machine joins the rear end of a coil in process to the leading end of the following coil to maintain a continuous feed through the plant. Whilst trimming and stapling are in progress the plant draws its feed from the coil stored in the accumulator, the operation of which is so arranged that its store is replenished as each successive coil is being processed. From the accumulator the strip passes through a multi-stage cleaning and surface preparation section followed by a drying and cooling station.

In the subsequent coating equipment the paint is applied by roll to a preset thickness on one or both sides of the strip, which then travels on through a multi-zone oven for baking. Leaving the oven the strip passes through a water spray and drying rolls before it enters a second looping accumulator. Beyond this accumulator is a shear which is used to cut out the section of stapled joint between each coil. The accumulator, working in reverse to that at the feed end of the plant, stores the continuous run of strip emerging from the plant whilst the shearing operation is effected and the leading end of a coil is locked on to the mandrel of a coiling machine.

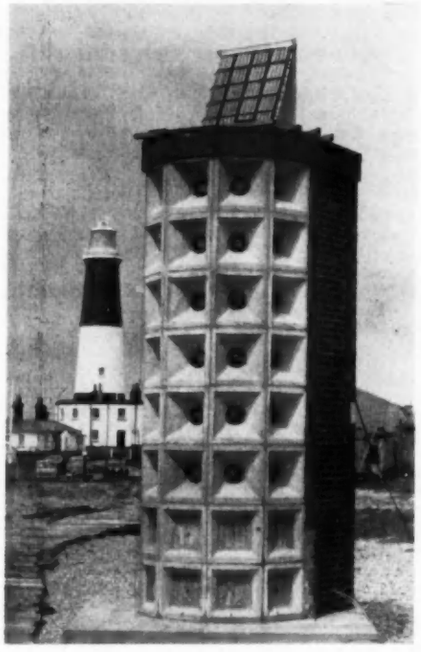
[Reply Card No. 1044]

Solar Cells for Buoy Lighting

AT present marine buoy lighting relies almost entirely on the use of stored gases, such as propane or acetylene. With the advent of the silicon photo-voltaic cell (solar cell), Trinity House research engineers turned their attention to its possible application to marine buoy lighting. One advantage of such cells is reliability, as has been demonstrated in experiments carried out by a manufacturer, Ferranti, Ltd., Hollinwood, Lancs, which showed that over a period of 20,000 hours there is no evidence of change in the device. It has a response time of a few microseconds and can operate without deterioration under conditions of high temperature (−40 deg. to +125 deg. Cent.) and humidity. The company's contribution to developing this source of energy was described in our February 5, 1960, issue.

In a long-term programme of research, Trinity House engineers have already established by practical tests at their headquarters and at the Dungeness research station, that despite the unfavourable English climate, solar cell installations can provide the necessary power throughout the year to charge a small battery. However, because of the many problems still to be solved, they do not anticipate that a fully-equipped marine buoy installation could be available for operation before the end of 1963. One experimental equipment takes the form of a spherical glass bulkhead fitting in which a block of four Ferranti MS 11E silicon solar cells, wired in series, are mounted at an angle of inclination of latitude +15 deg. This ensures that a maximum charge is given to the 1·2V Nife storage cell throughout the year. In peak sunlight conditions the maximum daily charge is of the order of 250mAh. Each cell provides about 7·4V on load.

A large experimental installation containing 400 solar cells wired in series parallel has been erected at Dungeness as illustrated; power derived from the bank is used to charge ten Nife storage cells. The installation is intended for use on navigational lights in river estuaries, and it is hoped that the investigations will decide whether such a scheme can be used successfully as the main source of power for operating a light without having to rely on a shore-based electrical installation.



Experimental installation of solar cells at the Trinity House research station, Dungeness

Continuance of the experiments depends on further evaluation of the economics of the solar cell power source. If it is decided to proceed, the next stage would be the construction of a model buoy which would be tested in a static water tank to determine the best physical configuration of solar cells mounted thereon when the buoy is subjected to the effects of wind and heavy seas. An arrangement would be sought which would ensure that even if some cells were shielded from light because of motion of the buoy, there would always be a surface generating sufficient power to charge a battery. The necessary information could be gained from the model by using only a small number of solar cells charging a single storage cell. A full-scale installation might employ a battery of nickel-iron alkaline cells of 45A capacity, switching power to operate a low-wattage filament lamp or xenon flash tube, and a transistor coder to give the desired flashing characteristic. A silicon light-sensitive cell might be used to switch off the coder and light at daybreak.

[Reply Card No. 1041]

Magnetic Core Memory System

As a result of the recent acquisition by the Ampex Corporation of Telemeter Magnetics, Inc., Culver City, California, Ampex Great Britain, Ltd., Arkwright Road, Reading, Berks, announces that it will now market the wide range of packaged standard memory systems produced by the new Ampex division. These systems, using square-loop ferrite core arrays, complete with the necessary solid-state electronics, have been designed to perform a variety of memory operations including random access, sequential load-unload, interlace load-unload, and other functions required for digital data storage and handling. Memory and address registers, load and unload counters, write drivers, read amplifiers and associated control circuitry are included as basic elements of these packaged devices. A memory cycle of six microseconds and an access of 2·5 microseconds are typical operation times.

[Reply Card No. 1043]

SHORTER REPORTS *(continued)*

Diffusion Furnaces for Transistor Production

HIGH-TEMPERATURE diffusion furnaces, designed and made by Royce Electric Furnaces, Ltd., Sheerwater, Woking, Surrey, have been installed in the transistor division of Standard Telephones and Cables, Ltd. The furnaces are used in the production of double-diffused silicon transistors.

As illustrated below, each furnace is a self-contained unit incorporating a floor standing cabinet which houses all the electrical gear including control instruments, switchgear and transformers. The equipments are suitable for use with nitrogen, oxygen and hydrogen atmospheres and are designed to take work tubes of either impervious alumina or transparent silica having an inner diameter of 2in. The furnace rating is 7½kW and the main dimensions are : length, 6ft ; width, 2ft 6in ; working height about 4ft.

Each furnace has both a preheat and a high temperature section, the preheat section being mounted on wheels so that it can be moved to and from the main chamber and locked in the required position. The preheat section has a heated length of 12in arranged in three zones and providing a range of temperatures from 200 deg. to 1000 deg. Cent. It comprises a high-grade refractory tube housed in a refractory lined chamber and carrying three separate heater windings of heavy gauge, nickel chromium wire. The heater currents are supplied through three variable transformers. The high-temperature section has a refractory tube in a brick-lined chamber of high-temperature refractory backed by thermal insulation. The heater length of 15in is controlled in one zone and provides any temperature required between 950 deg. and 1300 deg. Cent. Heating elements are of silicon carbide and are positioned vertically along the side walls of the chamber. Supply to the heaters is taken from a single-phase transformer having four primary tappings and a secondary winding with six coarse and six fine tappings.

In both sections the temperatures are independently controlled and, within specified temperature ranges, any desired temperature can be maintained in either section. Automatic temperature control is by indicating controllers, two instruments controlling the preheat section and a third, an anticipatory controller, operating the high temperature section.

A characteristic of the furnaces is the provision of even temperature zones, one 2in long in the preheat section, the other 3in long in the high temperature section. In these zones any specified temperature within their respective ranges can be maintained with a uniformity and a stability with time of ±2 deg. Cent. The furnaces are so designed that a fall in temperature cannot occur between these two zones.

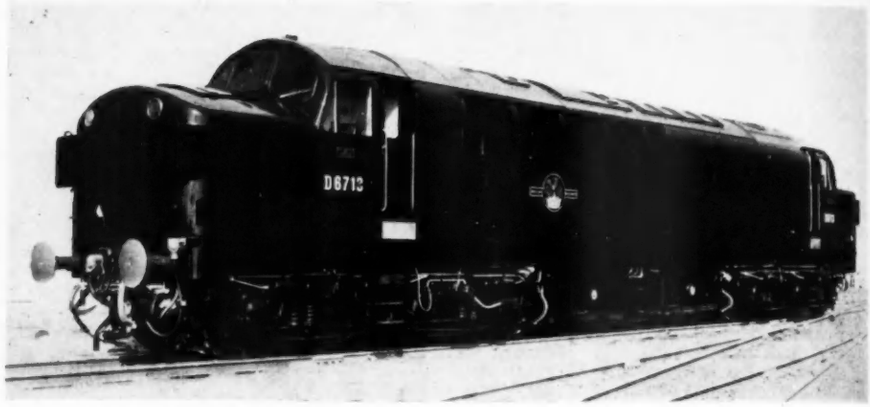
[Reply Card No. 1054]

Diesel Mixed Traffic Locomotives

A THIRD series of diesel locomotives in the type 3 power class (1500-1750 h.p.) is going into service on British Railways. It consists of seventy-nine main-line diesel-electric C_0-C_0 units supplied by The English Electric Company, Ltd., English Electric House, Strand, London, W.C.2, which are being allocated to the Eastern and North Eastern Regions. The locomotives have the twelve-cylinder vee-form 12CSVT engine with charge-air cooling as fitted in those supplied recently by the same company to the Sudan Railways and the East African Railways (described in February 19 and August 26, 1960, issues). In the present application the engine develops 1750 h.p. at 850 r.p.m. This compares with 2000 h.p. at 850 r.p.m. from the sixteen-cylinder version of the same engine, but without charge-air cooling, in the English Electric type 4 locomotives. The type 3 locomotives are being built at the works of the Vulcan Foundry, Ltd.

Previous type 3 series on British Railways, one diesel-electric (1550 h.p.) and one diesel-hydraulic (1700 h.p.) have had the B_0-B_0 wheel arrangement. Weight of the present 1750 h.p. locomotives in working order is 103 tons. The bogies have swing bolsters which carry the superstructure load on side bearers, and transmit it through nests of coil springs to spring planks suspended by swing links from the bogie frame. Thence the suspension is by further coil springs to equalising beams underslung from the axleboxes. Three axle-hung, nose-suspended traction motors are carried in each bogie.

Power is supplied to the traction motors from a 1107kW single-bearing main generator. The automatic load regulator is operated by a hydraulic vane motor instead of an electric pilot motor as in previous English Electric locomotives supplied to British Railways. Two steps of traction motor field weakening are provided by means of divert resistances, and the machines are connected in three parallel groups of two in series. At the top speed of 90 m.p.h. in weak field the tractive effort is 5400 lb. Maximum tractive effort is 55,500 lb, and the locomotive continuous rating is 35,000 lb tractive effort at 13·6 m.p.h.



1750 h.p. diesel-electric locomotive with charge-air cooled engine

All air taken into the interior of the locomotive passes through oil-wetted filters. The radiator consists of four panels, two at each side of the body, the outer pair dealing with the water circulating through the two charge-air coolers and the lubricating oil cooler, and the inner pair with the engine jacket and turbo-blower water cooling. The drive to the roof-mounted radiator fan is mechanical, through a right-angle gearbox and centrifugal clutch, but the two Northey 125RE exhausters and the Worthington-Simpson MSV 38S compressor have electric motor drives. A Clayton RO2000 train heating boiler is installed. At a future date, when electric train heating is required, this could be removed and a train heating generator interposed between the main and auxiliary generators.

The master controllers provide continuous variation of the diesel engine speed between 450 and 850 r.p.m. While changing from cab to cab the driver may leave the engine running, since the " engine stop " control is a button independent of the normal interlocking effected by the control key. Therefore the latter may be removed and used to unlock the second controller without stopping the engine. In addition to the normal access to the engine compartment from the cabs, entry can be gained through two side doors.

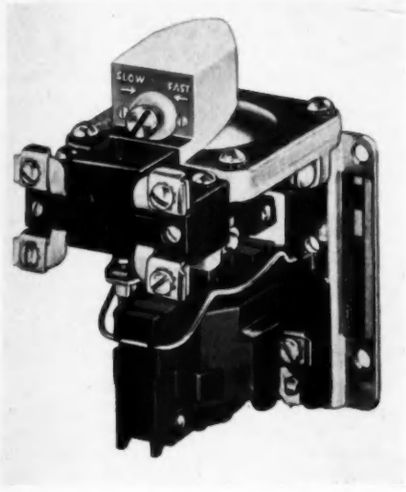
High-temperature diffusion furnaces for production of high-frequency, double-diffused, silicon transistors

Planning for Traffic

A SECOND convention, to be organised by the Institution of Municipal Engineers, will be held on October 5, 1961, at Central Hall, Westminster, S.W.1. It will be concerned with " Planning for Traffic," and follows last year's meeting on car parking. Mr. John Hay, M.P., Joint Parliamentary Secretary, Ministry of Transport, will officially open the convention. The papers to be presented are : " London's Traffic Problem," by Mr. J. Rawlinson ; " Planning for Road Traffic in the Counties," by Mr. J. Drake ; " Planning for Traffic in the Provincial City," by Mr. S. G. Wardley ; and " Planning for Traffic—Road and Rail," by Mr. C. W. King.

Time Delay Relay

We illustrate the class 5050 type A pneumatic time delay relay which has been developed by Square D, Ltd., Cheney Manor, Swindon, Wilts, from the existing class 8501 type D relay. Timing is adjustable from 0·2 second to one minute. The closed air circuit contributes to reliability by preventing ingress of foreign matter into the pneumatic system. Timers are available with delay after energisation of the magnet coil, or after de-energisation. Either form of relay



Relay with adjustable pneumatic time delay

can be converted to the other without additional parts. The single-pole, double-throw timed contact is available with pilot duty ratings up to 600V a.c. Coils have standard ratings up to 600V a.c. for 50 or 60 c/s. The relay has been designed so that conversions, adjustment and maintenance can be effected from the front of the panel. The terminals have pressure wire connectors and are also easily accessible from the front.

[Reply Card No. 1036]

Extruded Traced Tubes

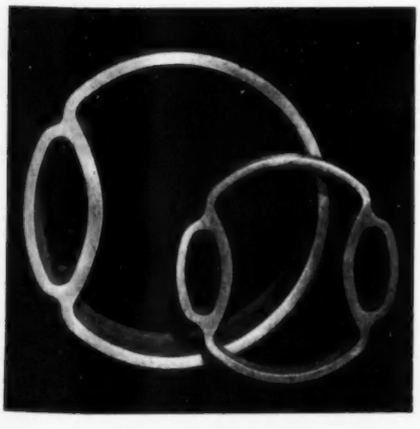
For use in the conveying of liquids which must be kept hot, to keep down the viscosity, or cold, there is now being marketed in this country by Imperial Aluminium Company, Ltd., "Unitrace" tube manufactured by the Aluminium Company of America.

"Unitrace" is an extruded aluminium alloy tube combining two integral channels, the larger for the product line, the smaller for the tracer line carrying the heating or cooling medium.

"Unitrace" is light and easily bent but has considerable strength and the integral construction provides excellent thermal characteristics. It is supplied in standard 30ft lengths and in seven standard sizes from 1in to 8in. The outside diameter of the tube conforms to standard pipe sizes so that normal insulation can be fitted. Special flange fittings enable "Unitrace" lengths to be bolted together by standard flanges or to jacketed fittings by means of adaptor flanges. Trace caps enable welded joints to be made on straight runs, tees and cross-connections. Right-angle elbows having trace lines at the side, outside or inside, are available.

The range has now been increased by the addition of "Duotrace," with two tracer lines instead of one.

[Reply Card No. 1055]



Sections of "Unitrace" and "Duotrace" extruded tubes with integral tracers for heat exchange

Industrial Space Heater

An addition has been made to the range of "Dravo" space heaters to meet the needs of smaller industrial buildings. The heaters are marketed by Powell Duffryn Modulair, Ltd., Vale Road, Camberley, Surrey, and manufactured by the Coventry Radiator and Presswork Company, Ltd. With an output of 300,000 B.Th.U. per hour the model 30 (illustrated) is suitable for heating factory bays of up to 80,000 cubic feet and a wide range of premises, such as garages, public halls, show rooms, and similar buildings. Like the larger units, the new model has a stainless steel combustion chamber and a four-pass flue gas travel system. The heater also includes directional

Gas- or oil-fired space heater with directional nozzles and induced draught exhaust

nozzles enabling the warm air to be directed where required, and an induced draught exhaust which eliminates the need for a high flue-stack. Ducting can be connected to the top of the heater to convey heat to partitioned areas.

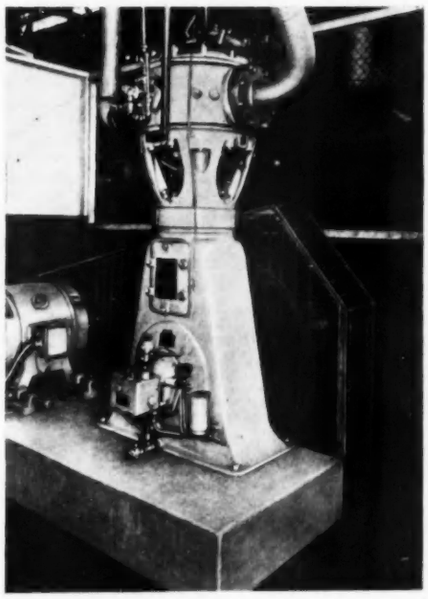
The model 30 is available with either gas or oil firing. Maximum fuel consumption is 2·25 imperial gallons per hour, and air output 3250 cubic feet per minute. The blower fan motor is a single-phase or three-phase machine of 1 h.p. Dimensions of the heater are: overall height 101½in; length 45⅛in; width 30⅜in; and stack diameter 6in.

[Reply Card No. 1042]

Heavy Duty Air Compressors

We illustrate below a typical model in a new range of air compressors rated for twenty-four hour heavy duty applications introduced by Joy-Sullivan, Ltd., of Greenock. This vertical, single-cylinder, single-stage, water-cooled compressor is available in six cylinder stroke sizes giving free air delivered outputs of 75 to 334 cubic feet per minute at working pressures of 15 lb to 150 lb per square inch.

All parts of the compressor which are subject to wear are replaceable, including the cylinder liner which is made of special alloy iron and honed to close tolerances. A truncated aluminium piston permits inclined setting of the valves in the cylinder head, and is claimed to impart improved heat and air transfer and extend valve life. The valves of low lift "Dual Cushion" design have stainless steel components, and conventional coil springs are replaced



Heavy-duty air compressor made in six sizes covering free air deliveries from 75 to 334 cubic feet per minute

by a wave formation, variable reaction, valve spring in contact with a reaction plate of similar design. In action, the spring and plate work in conjunction to absorb valve plate shock at both top and bottom of lift. Valve operation is claimed to be smooth and quiet, while the large port areas together with large streamlined air passages in the valve cage ports give virtually unrestricted air transfer.

The crosshead is of one-piece, box type construction and has bearing surfaces grooved for full pressure lubrication. Heavy duty self aligning ball bearings are fitted throughout and lubrication is by a rotary-gear pump mounted on the non-drive end of the crankshaft. This pump supplies filtered oil under pressure to connecting rod top and bottom ends, and crosshead guide, the main bearings and revolving members being splash lubricated. On the smallest compressors all moving parts are lubricated by a controlled force-splash system.

Standard control equipment is designed for conditions in which air demand is steady and approaches maximum compressor capacity. Unloading is effected automatically by inlet valve control in accordance with system demand and is governed by an automatic pilot system.

An alternative dual control system covers applications where air demand is intermittent, and has a transfer switch which permits either constant speed regulation or automatic start/stop regulation. An electro-pneumatic pilot system maintains the unloaded condition during both starting and stopping phases of the cycle. Special means of regulation can be supplied for particular applications such as gas compression and process work.

[Reply Card No. 1037]

SHORTER REPORTS *(continued)*

New Alloy Steel

SAMUEL FOX AND CO., Ltd., a subsidiary of the United Steel Companies, Ltd., has started commercial production of a new alloy steel designed for service temperatures up to 675 deg. Cent. Known as "Esshete 1250," this austenitic creep-resisting steel is a 15 per cent chromium, 10 per cent nickel, 6 per cent manganese steel, the composition including smaller percentages of silicon, molybdenum, vanadium, niobium and boron. It combines a high level of rupture strength with adequate ductility, good weldability, structural stability and oxidation resistance at elevated temperatures for long periods. It also has good manipulation properties, and has proved satisfactory in the production of bars, tubes, pipes and large forgings ; sheet trials are in progress. Large bars, pipes and plate can be readily fabricated in either the hot or cold condition, cold forming being understood to include temperatures not exceeding 650 deg. Cent. and hot forming, not less than 900 deg. Cent. Whichever method of fabrication is adopted, the material requires a resolution treatment within the range 1050 deg. to 1150 deg. Cent.

The structural stability of the steel compares most favourably with other more conventional austenitic steels. Its oxidation resistance has been assessed by a combination of laboratory tests and exposure in an experimental element in a power station for a period of approximately two years, where it has shown similar characteristics compared with other austenitic steels of the same chromium content. Mechanical properties are shown in Table 1.

Particular attention has been devoted to the stress-to-rupture properties of " Esshete 1250," the test programme having covered a period of 25,000 hours to date. The results of this extensive testing are summarised in Table 2.

Creep testing up to 10,000 hours has been carried out to determine the stress to give 0·1 and 0·2 per cent strain (Table 3).

Like other austenitic steels in the solution-treated condition, " Esshete 1250 " has low proof stress values. These can be improved by warm working, and this process is found, in fact, to push up the 0·1 per cent proof stress to 32 tons per square inch at room temperature and 23 tons per square inch at 625 deg. Cent., while still holding elongations on 4A of the order of 48 and 25 per cent respectively. The hardness of the steel is not altered at 625 deg. Cent. but at room temperature is the equivalent to 43 tons per square inch ultimate tensile strength, which is only slightly more than in the normally rolled condition.

[Reply Card No. 1048]

Typical Mechanical Properties—Solution Treated

TABLE 1

Test temperature (deg. Cent.)	Tensile strength (Tons per square inch)	Proof stress (Tons per square inch) (0·1)	(0·2)	Limit of Proportionality (Tons per square inch)	4A (per cent)	Reduction of Area (per cent)	Modulus of elasticity (Tons per square inch)
20	39·0	13·8	15·0	7·0	67·0	69·6	13,400
100...	34·3	10·6	11·6	5·2	64·5	72·0	13,000
200...	31·8	9·9	10·1	4·2	55·0	70·3	12,500
300...	31·4	8·5	9·4	3·6	45·0	64·0	11,900
400...	31·5	8·6	9·1	4·4	47·7	60·8	11,300
500...	30·3	8·2	8·8	4·8	40·5	60·8	11,700
600...	28·5	8·2	8·6	4·8	47·4	64·0	10,200
700...	23·0	8·1	8·5	3·6	40·0	51·2	9,650

TABLE 2

Time (hours)	Degrees Centigrade 600	625	650	675	700
	Tons per square inch				
100	24·0	20·5	18·0	16·3	15·5
300	22·0	18·5	10·5	15·1	14·6
1,000	20·0	17·0	15·0	13·5	13·0
3,000	18·5	16·0	14·0	12·0	10·0
10,000	16·8	14·5	12·5	10·4	7·5
100,000	(15·0)	(13·3)	(11·4)	(8·9)	(5·8)
	(13·9)	(12·5)	(10·8)	(8·2)	(4·5)

TABLE 3

Deg. Cent.	Stress for 0·1 per cent Creep Strain (Tons per square inch) 1000 hours	3000 hours	10,000 hours	Stress for 0·2 per cent Creep Strain (Tons per square inch) 1000 hours	3000 hours	10,000 hours
650...	7·60	6·00	5·15	7·80	7·25	6·65
675...	6·55	5·45	4·70	7·30	6·50	5·60
700...	4·90	3·60	1·80	5·60	5·30	3·10

Industrial Shunting Locomotive

AN addition to the range of industrial diesel shunting locomotives manufactured by John Fowler and Co. (Leeds), Ltd., Hunslet, Leeds, 10, is a 203 h.p. unit with three-stage torque-converter transmission. Previous locomotives supplied by this builder have had either fluid couplings or single-stage torque converters in conjunction with air-operated change-speed gearboxes and forward/reverse final drive units.

The new locomotive is in production in a 28-ton 0–4–0 version (illustrated), and in 30-ton 0–6–0 form. It is available in gauges from 1m to 5ft 6in. The power unit is the B.U.T./Leyland U.E.902, six-cylinder, four-stroke, direct injection, diesel engine, with cylinders of 5·5in bore by 6·5in stroke, and 15·50 to 1 compression ratio. In this application it is rated to develop 203 b.h.p. at 1800 r.p.m. (twelve-hour continuous rating). A mechanical all-speed governor is integral with the injection pump unit.

Incorporated in unit construction with the engine is a British Twin Disc 10,000 series three-stage torque converter. An overcentre clutch between engine and torque converter is air-operated, and functions automatically when changing direction, its control being combined with the forward/reverse lever in the cab. From the torque converter the drive is taken through " Layrub " couplings and cardan shaft to a Wiseman 15. R.L.G.B. reversing and final drive unit which is bolted to the main frame to form a rigid stay. The spiral bevel reversing gears are followed by spur reduction gearing to the jack-shaft. Maximum starting effort is 18,000 lb, and top rail speed is 15 m.p.h., at which the effort is 1400 lb. The transmission oil, taken from the engine fuel tank, is cooled in a heat-exchanger.

As seen in the illustrations, all-round visibility and simplicity of control layout have been specially studied. Driving controls are duplicated for use at either side of the cab. The tall levers for sanding and horn operation are well spaced from the others and come readily to hand. Instruments and electrical switches are grouped on a central panel. The larger dials at the four corners show engine revolutions per minute, air pressure, locomotive speed and lubricating oil pressure. Torque converter fluid temperature and pressure, cooling water temperature and battery charging current are read from the smaller dials.

[Reply Card No. 1046]

(Left)—Diesel-hydraulic 203 h.p. shunting locomotive (Right)—Duplicated driving controls and central instrument panel in the cab

INDUSTRIAL NEWS

Trading Opportunities in West Germany

The Export Council for Europe has now published its second report. A team of eight men, drawn from members of the Council and led by Sir William McFadzean, its chairman, toured the main industrial centres in West Germany in May and the report contains their findings and recommendations. In a message from the chairman with which the report is introduced, Sir William says that British exports to West Germany have trebled since 1955 and doubled since 1958 and, including re-exports, are now running at the rate of about £190 million per annum. This still represents less than 5 per cent of present imports, Sir William adds, and the mission has no hesitation in saying that these figures could and should be substantially increased.

Although there will always be a market for specialised equipment the team feels that the present position in West Germany has revealed additional opportunities for such goods as electronic equipment and components, machine tools for metal and woodworking, marine pumps and engines, specialised tools for aircraft and shipbuilding industries, factory trucks, refrigeration equipment, printing machinery, textile machinery, laundry equipment, scientific and measuring instruments, earth-moving equipment, land draining equipment, and iron and steel goods.

Construction equipment of all kinds is in demand, the report says, but must comply with stringent building and safety regulations. Agriculture in West Germany so far is not as highly mechanised as in Britain and there is a growing market for all types of machinery and implements. Any agreement within the European Economic Community which might expose German agriculture to greater competition from its partners would, the report suggests, tend to accelerate the trend towards mechanisation.

There were no complaints regarding the quality of British machine tools. On the contrary, the report states, German users acknowledged them to be amongst the finest available, although some designs were considered old-fashioned.

Much could be done, the team says, to increase the sale of British cars in Germany. In spite of isolated and commendable successes the general story was one of criticism, the report adds, " especially because of the difficulty of getting British spare parts locally and, the lack of an adequate after-sales service. There is definitely a market for certain types of British cars in West Germany, the report continues, particularly the larger models and sports cars, but no general expansion can be looked for until the valid criticisms have been met.

Industrial Pollution

The ninety-seventh annual report of the Chief Alkali Inspector for England and Wales was published last week. During 1960 specific complaints concerning 292 works were investigated, compared with 354 complaints in 1959 and 133 in 1957. There were forty-seven complaints against ceramic works, thirty-three each against gas and coke works and iron and steel works, thirty two against electricity works, fourteen against aluminium works and eleven against cement works.

The report records that over the years the problem in the cement industry has changed from one of smoke and smell to that of dust emission. The treatment of dust-laden gases leaving the kilns is one of the least tractable of the many problems. With new kilns or new works the problem can be minimised, the report says, by suitable location of chimney, electric dust precipitator and kiln, but the main problem is with existing kilns and chimney arrangements, in which long flues are unavoidable. Co-operation in the tar industry during the year has been good, the report says, and great progress has been made, especially with larger installations and works.

In its references to power stations, the report says that the inspectorate's main preoccupation has been with the medium-sized power stations, in which the main task is to ensure that the grit arrestment plant is maintained in an efficient state. Power stations burnt over 1,000,000 tons more oil in 1960 than in 1959, and this method of fuelling gives rise to the problem of acid smuts. " Despite intensive study," the report says, " a complete and general remedy applicable to all power stations is not yet in sight."

Beginning with the present report, some of the older processes registered under the Alkali Act are being selected for historical and technical review. The report deals with alkali, cement and tar works in this way, and there is also a review of alkali waste tips.

Industrial Trends

The Federation of British Industries has published a report on its eleventh enquiry into industrial and export trends in this country. The results reported four months ago (THE ENGINEER, February 17, 1961) suggested falling orders and rising stocks, an easier labour position and lessening optimism. But the Federation pointed out at that time that detailed expectations gave some hope that the trend might be halted. The latest returns prepared at the beginning of June by 701 industrialists, show that this has happened. There has been a revival in new orders, the Federation says, a consequent lengthening of order books, and an increase in output.

Labour is again given as the main impediment to increased output, whereas, in February, orders or sales had, for the first time, become the major factor. Stocks at all levels have again risen, the Federation says, this being in marked contrast to the expectations that raw material stocks would fall and finished goods and work in progress would remain steady. The balance of firms reporting a rise in costs in the previous enquiry, was the highest since the enquiries began. This time, the Federation says, a further substantial rise in costs is suggested, coupled with a much smaller rise in selling prices and a further lessening of profit margins. The increase in the balance of firms reporting a rise in costs and a fall in margins has been greater than expected, and the Federation suggests that the rise in the tax on fuel oils may have contributed to the situation.

The Federation has also made a detailed enquiry into exports and the analysis contained in the report is based on the replies from the 499 respondents for whom exports were significant. Thus some 70 per cent of the sample of 701 large, medium and small firms taking part in the enquiry into industrial trends were exporting directly. Over all, the Federation says, about 25 per cent of their output was exported, a figure which is consistent with published statistics. The answers to the questions on the rates of new orders and on deliveries show a significant improvement for the first time since a year ago, although, the Federation points out, the improvement is less than that shown for the home trade. The replies also show that despite a rise in export orders on hand, delivery dates have been shortening somewhat and that more orders have been booked at lower prices. This is in contrast to the reported rise in prices for the home market, and the general rise in unit costs of production.

The most disturbing factor to emerge from this enquiry into export trends, is the continuing rise in production costs, the Federation says, particularly as price is seen to be the main obstacle to higher exports.

Iron and Steel

According to the monthly production statement issued by the Iron and Steel Board, the production of steel in May was at an average rate of 466,100 tons a week compared with 471,600 tons a week in April and with 475,400 tons a week in May, 1960. The Whitsun holiday fell in May this year, but not in 1960, and allowing for the effect of this, the production of steel last month was at about the same level as a year ago.

Orders received by the steel producers from the home users have been running below the rate of deliveries for several months. Order books have shortened and most products are now available with early delivery.

It has been estimated that during the first quarter of 1961, consumers' and merchants' stocks of finished steel rose by 92,000 tons or 2 per cent, compared with an increase of 200,000 tons during the first quarter of 1960. There has been no significant change in the consequential estimate of the use of steel in the home market in the first quarter which remains at an increase of 1½ per cent above that used in the first quarter of 1960.

The Iron and Steel Board has also announced that it has decided to increase the maximum prices of iron and steel products permitted to be charged in the United Kingdom by iron and steel producers by 1 per cent on all items with effect from June 19. The total finished output of the industry for sale at home and abroad is approximately 18,000,000 tons, the Board says, and the increase in price represents just over 10s. per ton on the average.

The British Iron and Steel Federation states that the industry considers the increase now given to be totally inadequate having regard to the recent additional cost burdens on the industry. The consequential increase in the industry's earnings has been estimated at a rate of £7,500,000 a year over the second half of 1961, whilst over the same period, the Federation says, additional costs have been estimated at a rate of about £25,000,000 a year net.

PERSONAL AND BUSINESS

Appointments

MR. JAMES SCOTT has been appointed a director of Thermotank, Ltd.

MR. GEORGE TALBOT has been appointed deputy managing director of Stein and Atkinson, Ltd.

MR. J. S. HONESS, Grad. I.E.E., has been appointed sales planning engineer of George Ellison, Ltd.

MR. G. P. PHILLIPS has been appointed to the main board of Prodorite, Ltd., as sales director.

BABCOCK AND WILCOX, Ltd., has announced that Sir Noel Hall and Mr. L. W. Cole have been elected directors.

MR. JOHN HAYWARD has been appointed public relations officer of The General Electric Company, Ltd.

GENERAL SIR BRIAN ROBERTSON has accepted an invitation to join the board of the Dunlop Rubber Company, Ltd.

DEWHURST AND PARTNER, Ltd., has announced the appointment of Mr. R. A. Nisbet, A.M.I.E.E., as regional manager (south).

THE GISHOLT MACHINE COMPANY (GREAT BRITAIN), Ltd., announces the appointment of Mr. S. W. Perkins to the board of directors.

BRITISH HYDROCARBON CHEMICALS, Ltd., announces the appointment of Mr. G. Peters as works general manager at its Baglan Bay factory.

ADAMANT AND WESTERN ENGINEERING, Ltd., announces that Mr. F. V. Waller, managing director of the Group, has been appointed deputy chairman.

THE LAMBRETTA/TROJAN GROUP OF COMPANIES, announces the appointment of Mr. Norman Hands as assistant sales manager of the Lambretta scooter division.

MR. C. A. BELL has been appointed secretary of Richard Costain, Ltd., in place of Mr. J. B. Parret who, as announced earlier, has been appointed a director of the company.

MR. R. F. G. LEA, deputy chairman and joint managing director of CIBA (A.R.L.), Ltd., Duxford, Cambridge, has been appointed a director of CIBA Clayton, Ltd., Manchester.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION, announces the appointment of Mr. Basil H. Tripp as editor of its internal and external publications concerned with research work in the steel industry.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., states that Mr. E. Heys, A.M.I.E.E., has been appointed manager, electronic sales department (Manchester) of the A.E.I. electronic apparatus division.

THE INSTITUTE OF FUEL announces that Dr. James Burns, deputy chairman of the North Thames Gas Board, has been elected president to take office in October, 1961. Sir Harold Hartley has been made an honorary member of the Institute.

ASSOCIATED ELECTRICAL INDUSTRIES (MANCHESTER) Ltd., has appointed Mr. R. Crummack as superintendent (process and rate) and Mr. R. G. Nicholas superintendent (production engineering services), both in the Manufacturing Services Department.

WALKER CROSWELLER AND CO., Ltd., states that Mr. C. F. Taylor, previously general manager of the company's Leonard mixing valve division, has now been appointed sales director and Mr. D. A. Launchbury is now a director as well as secretary of the company.

MR. ROBERT ALLEN COURTMAN, senior executive at Armstrong Whitworth Aircraft, Ltd., Coventry, has been appointed production manager of Hawker Siddeley Aviation, Ltd. Mr. Courtman's duties as senior executive at A.W.R. will be taken over by by Mr. G. E. Hayward.

MR. A. T. WRIGHT will retire on Juhe 30 from the position of director and manager of The Tanker Insurance Company, Ltd., the insurance organisation of The British Petroleum Company, Ltd. He will be succeeded as manager by Mr. D. Southworth, who is at present deputy manager.

THE ROYAL INSTITUTION OF CHARTERED SURVEYORS states that the following officers have been elected for 1961-62 : Mr. E. C. Strathon, president ; Mr. G. H. Heywood, senior vice-president ; Mr. C. D. Pilcher, Mr. G. D. Walford and Mr. Henry W. Wells, vice-presidents and Mr. E. Harold Palmer, honorary secretary.

MR. O. C. KERRISON has retired from the chairmanship of the Paterson Engineering Company, Ltd., and from the directorate of the various associated companies in the Group with effect from May 1, 1961, after fifty years service. Mr. John V. Sheffield has taken over the chairmanship of The Paterson Engineering Company, Ltd.

MR. OWEN A. LAURITZEN, timber development director of the British Columbia Lumber Manufacturers Association in the United Kingdom, has been appointed promotion manager, with responsibility for development work in the home and overseas markets. Mr. R. C. Bennet, who joined the Association's United Kingdom organisation at the beginning of this year has assumed the responsibilities of timber development director in this country as from June 1.

KERRY'S (GREAT BRITAIN), Ltd., parent company of the Kerry Manufacturing Group, announces the following appointments :— Mr. P. K. Hart has been appointed assistant managing director of the three manufacturing units in the northern group, Qualters and Smith Bros., Ltd., Henry Broadbent, Ltd., and Oldfield and Schofield Company., Ltd, and will be making his headquarters at the Oldfield and Schofield Works ; Mr. C. Goulding, who has been with Qualters and Smith Bros., Ltd., for many years has been appointed factory manager. Mr. J. Dunkerley has been appointed works director of Oldfield and Schofield Company, Ltd., in addition to his duties as works director of Henry Broadbent, Ltd. Mr. C. Schofield will continue as a director of Oldfield and Schofield Company, Ltd.

Business Announcements

WALMORE ELECTRONICS, Ltd., 11-15, Betterton Street, Drury Lane, London, W.C.2, has been appointed the United Kingdom distributor for the products of Motorola Semiconductor Products Inc.

CROFTS (ENGINEERS), Ltd., states that its London office has been moved from 34, Norfolk Street, Strand, W.C.2, to new premises at 36/42, Tanner Street, Bermondsey, S.E.1, (telephone HOP 7751/4).

THE ARGALL MACHINE TOOL Company, Ltd., 162, Buckingham Palace Road, S.W.1, announces that it has been appointed sole agent for the United Kingdom and Commonwealth for the "Personer" range of baling presses.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., Heavy Plant Division, has established a service department, with headquarters in Rugby, to co-ordinate after-sales service for all its products. Manager of the department is Mr. B. M. Swift.

SANDFORD FAWCETT AND PARTNERS, Consulting Engineers, 53, Victoria Street, London, S.W.1, announce that they are taking into partnership Mr. J. Hutchinson, M.I.C.E., M.I.P.H.E., and Mr. R. D. Sheffield, M.I.C.E., M.I.W.E.

VOKES GROUP, Ltd., announces that that Mr. C. G. Vokes, the founder of Vokes, Ltd., and managing director of that company until 1950, has retired from the board of Vokes Group, Ltd., and from the boards of its various subsidiary companies, with effect as from the June, 12 1961.

PRESS AND SHEAR MACHINERY COMPANY, Ltd., 172-178, Victoria Road, London, W.3, has been appointed distributors in the United Kingdom for the double crank power presses manufactured by Hubert-Juy-Legros, of 99, Avenue Rue General Michel-Bizot, Paris, Xiie, France.

FLEXIBOX, Ltd., Manchester, has concluded an agreement with Alfred Herbert, Ltd., Coventry, under the terms of which Alfred Herbert, Ltd., is appointed sole agent for the United Kingdom for the sale of the Flexibox range of lapping machines. The agreement came into force on the June 1.

ALCAN INDUSTRIES, Ltd., formerly Northern Aluminium Company, Ltd., announces that as from July 1, 1961, its Luton sales office territory will take in Oxfordshire and the southern portions of Buckinghamshire, and Essex hitherto covered by its London sales office. The Luton office, at 57, Bute Street, Luton, now assumes Area status.

MELANOID, Ltd., Dudley Port, Tipton, Staffs., a subsidiary company of the West Midlands Gas Board, is being voluntarily wound up. A liquidator has been appointed as from June 19, 1961 and the staff have been offered alternative employment. Griffiths Bros., and Co., London, Ltd., Armour Works, Well Lane, Wednesfield, Staffs., who has hitherto handled the sales of Melanoid paints in the United Kingdom, has now taken over manufacture of the products and will in future distribute them to all parts of the world through its agency network.

Contracts

THE STANTON IRONWORKS COMPANY, Ltd., near Nottingham, has secured a contract for the supply of 300mm to 650mm spun iron pipes, valued at approximately £200,000 to be used for extensions to the Alexandria Sewage System.

W. AND T. AVERY, Ltd., has received an order worth over $115,000 from the National Harbours Board of Canada for three automatic grain weighers each having a capacity of 20,000 lb per weighing. These will, it is claimed, be by far the largest gravity operated machines of their type in the world.

G.W.B. FURNACES, Ltd., has received an order for what it is claimed will be the largest and most powerful high-frequency induction melting furnace in the United Kingdom. The furnace will be installed at the works of the North Eastern Iron Refining Company, Ltd., Stockton-on-Tees. It will be fitted with a body capable of holding up to 7 tons of molten metal, but the electrical equipment has been so designed that a second furnace body of 10 tons capacity can be fitted.

THE HEAD WRIGHTSON MACHINE Company, Ltd., has received orders for a plate levelling line and two sheet levelling and oiling lines from Colvilles, Ltd. The plate line, which will be installed at Ravenscraig Works, will handle hot rolled plate up to $\frac{5}{8}$ in thick, 5ft 3in wide and 30ft long. Both the sheet lines will be installed at Colvilles' Smith and McLean Gartcosh Works. They will handle sheets cut from cold rolled strip in gauges from 0·011in to 0·111in thick, and will be used on special orders for flattened and oiled sheets.

Awards

THE MINISTRY OF EDUCATION is offering three Whitworth Fellowships for 1962 to practising engineers who wish to follow a course of training, study or research at postgraduate level in an approved establishment or industrial organisation in this country or overseas. The awards are worth £1,000 a year plus additions for dependants, travelling and subsistence where appropriate. In addition three Whitworth Exhibitions of £100 will be awarded to unsuccessful candidates whose work deserves recognition. Applicants must be over twenty-five years of age and be in possession of a university degree in engineering, a Diploma in Technology (Engineering), a Higher National Diploma or Certificate in engineering with at least two distinctions, or of a qualification approved by the Minister of Education as of equivalent standard. They must have been subsequently engaged as practising engineers for not less than three years. Women who satisfy the conditions are eligible to compete.

Death

WE regret to record the sudden death of Mr. F. H. Houghton, A.M.I.E.E., on June 8. He had been Industrial Cable Sales Manager with Crompton Parkinson Ltd., since 1945. Mr. Houghton joined the company in 1936 as a Cable Salesman, and then was appointed Manager of the Portsmouth Branch in 1939. After three years in that position he joined the Ministry of Supply, Cable Planning Authority, where he remained until the end of the war.

Miscellaneous

MOTOR VEHICLE STATISTICS.—The May, 1961, issue of the *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders, Ltd., contains the results of a census of vehicles registered in Great Britain at any time during September, 1960. Cars totalled 5,525,828, of which 4,851,438 were in England ; the largest number in any county was 421,621 in Yorkshire. Hackneys totalled 93,265 and goods vehicles 1,397,086.

VICKERS, Ltd., Vickers House, Broadway, Westminster, London, S.W.1, wish it to be known that the order for the design and supply of two beet sugar factories to Russia mentioned on page 1003, THE ENGINEER, June 16, 1961, refers to the order received and announced a number of months ago by Vickers and Bookers, Ltd. This is the joint company formed by Vickers, Ltd., and Booker Brothers McConnell and Co., Ltd., to handle such projects.

CONTINENTAL AFFAIRS

by Our Continental Editor

Steam Engine Smoke Stack Device

A SMOKE stack device introduced on the Hungarian State Railways is claimed to increase the horse-power capacity of a steam engine by over 20 per cent, compared with a similar engine fitted with the traditional blast nozzle. The "Ister" design of smoke stack device (Fig. 1) has a convergent nozzle in the shape of a five-armed star, analogous to a jet engine silencer and similar in its mode of operation. The discharge end is near the inlet of the smoke stack. The jet periphery is greatly increased above that of a round jet with the result that the flue gases are entrained much more smoothly and efficiently and the vacuum in the smoke box is improved. The area of the jet is twice as large as normal.

With the old design, the exhaust steam tends partly to expand in the smokebox and spoil the

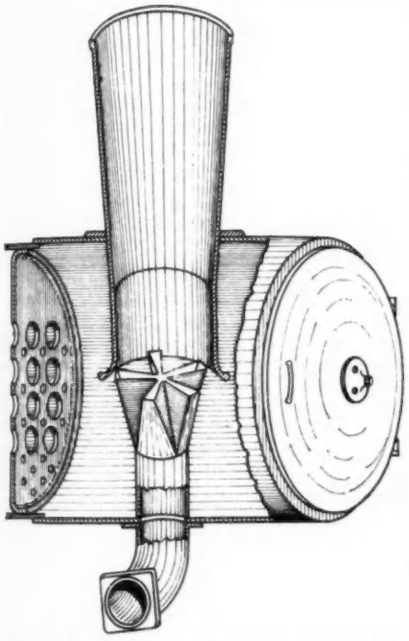


Fig. 1—Principle of "Ister" smoke stack device. The five-armed, star-shaped nozzle extends to the mouth of the smoke stack

vacuum if the excess steam pressure in the discharge pipe ahead of the blast pipe is greater than the critical value of 0·8 kg per square centimetre. In the "Ister" device the cross-section is such that similar excess pressures cannot occur even as transients either at low or high engine speeds.

In comparing the new with the old design, it must, however, be remembered that the slide valve box pressure, the speed, and the indicated horse-power capacity of the two engines must be of the same order. Fluctuations of up to 20 per cent may appear in fuel consumption which depend entirely upon the performance of the crew. The saving in fuel consumption as a result of installing the device depends chiefly on the rating of the engine. Because Hungary is predominantly a flat country the loading of the engines is slight, and the trains are light owing to the short distances. If advantage is taken of the greater output capacity conferred by the device, to run the train at a greater speed, there will not be any net savings in fuel, since at the higher speed the rate of fuel consumption will be significantly higher. In any case, the savings in fuel made over a period of normal running are less than the savings nominally possible because in normal operation stops, &c., must be included. When the engine is idling or standing still it continues to use up fuel, although there is then little or no steam consumption. On the other hand, occasional savings greatly exceed the nominal figure, as normally the pressure in the valve box is considerably lower than 11 kg per square centimetre owing to the action of the throttle.

Other advantages are stated to include a reduction in wear of the connecting rod bearings, since because of the lesser counterpressure on the piston the compression will start at a lower figure. Fly ash is also reduced in amount since less steam is required in the blast, i.e. significantly less vacuum in the smoke box, for the same horse-power capacity.

The discharge of exhaust steam from the cylinders in the form of intermittent blasts is a distinct disadvantage, especially at low engine speeds and with coal of low specific gravity, which is easily sucked up from the grate. If required a shock damper is fitted underneath the smoke box. The exhaust steam first flows into this tank, and then in to the blast pipe.

The effectiveness of the device is illustrated in Fig. 2 which is drawn for a Hungarian State Railway Series 324 engine going at a driving wheel speed of three revolutions per second. This design has two cylinders of 510mm bore and 650mm stroke. The boiler operates at 12 kg per square centimetre gauge and has a heating surface of 154·6 square metres. At maximum speed of 75km.p.h. the driving wheels rotate at 4·6 revolutions per second. The old smoke stack device had a cross section of 86·5 square centimetres, while the "Ister" device has a section of 148 square centimetres. Curve I shows the indicator diagram obtained with the normal jet, and II with the "Ister" device. In the latter case the cut-off is reduced from 30 to 25 per cent, and the discharge pressure is decreased from 0·66 kg per square centimetre to 0·18 kg per square centimetre. In both cases

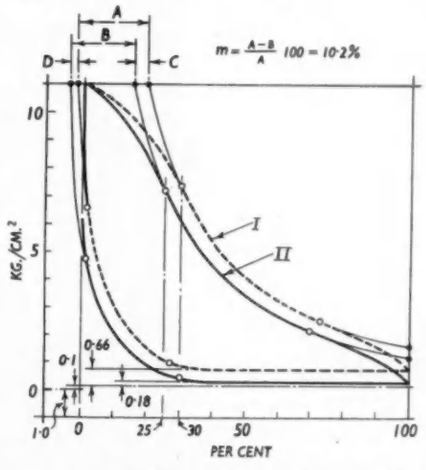


Fig. 2—Indicator diagrams (I) normal smoke stack, (II) smoke stack equipped with patent device

the back pressure on the piston is 0·1 kg per square centimetre above the discharge pipe pressure. The steam saving $m=(A-B)/A\times100 = 10{\cdot}2$ per cent, and the saving in fuel is similar.

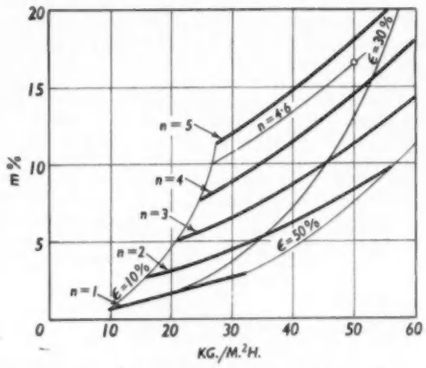


Fig. 3—Steam raising m as a function of boiler load (kilogrammes per square metre per hour), speed (revolutions per second) and cut-off E, achieved by using the special stack device

Fig. 3 relates the steam saving m, the boiler loading (kilogrammes per square metre hour), the driving speed n (revolutions per second) and the percentage cut off ε.

Russian Neutron Pulse Reactor

A fast neutron pulse reactor, stated to be the first reactor to operate cyclically in super-critical conditions, has come into service at the Joint Nuclear Research Institute at Dubna, outside Moscow.

In conventional reactors the presence of control rods limits the reactivity to a safe value by absorbing excess neutrons, and so prevents the reactor from blowing up as the result of the fission avalanche which would would otherwise result.

The new device, the idea for which was suggested in 1955 by the Soviet physicist Dmitry Blokhintsev, makes use of a different control principle. The core is divided into two parts, one stationary, the other embedded in a rapidly rotating disc. A super-critical state occurs at the moment when the rotating core reaches the vicinity of the stationary core. Because of the high speed of rotation, the duration of the super-critical condition is maintained for only a few micro-seconds. In this way, the growth of the neutron avalanche is limited to a safe value. The reactor thus emits a series of very powerful neutron pulses. Fast neutrons obtained in this way are sent into a 1000m long neutron guide and other experimental channels. The arrangement, it is claimed, makes possible the setting up of more delicate experiments than is the case with traditional reactors, and effects a great saving of nuclear fuel because of the low average power at which the reactor is maintained.

The fast neutron pulse reactor is stated to have passed its running tests and to have achieved its specified performance. It will provide the experimental basis of the neutron physics laboratory which was recently established at the Joint Institute under the Nobel Prize winner, Professor Ilya Frank. Equipment scheduled to be used in conjunction with it includes analysers recording high-speed neutron pulses.

The reactor will be used in low energy nuclear research, for studies of material structures, &c., and also in connection with practical applications.

CONTINENTAL AFFAIRS *(Continued)*

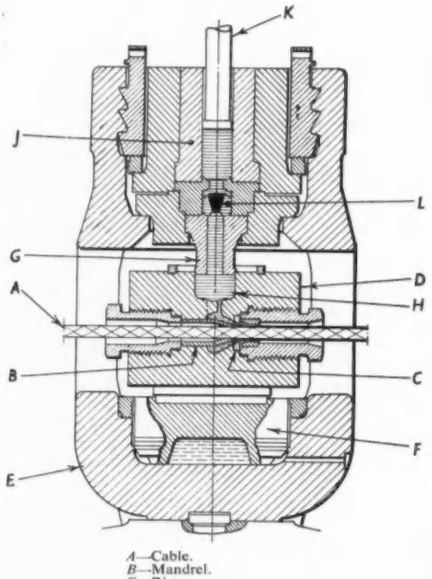
Continuous Cable Sheathing Press

A cable sheathing press in which long lengths of cable can be encased in aluminium without the necessity of stopping periodically for inserting new slugs, has been developed by Hydraulik G.m.b.H., Duisburg, and is now in operation.

In the conventional sheathing process, the cable passes through a convergent mandrel which projects into the cavity of an extrusion die and is in line with an extrusion ring having an opening equal to the outer diameter of the sheathed cable. A slug of metal is forced by the press into the die cavity and flows out through the annulus between the cable and the ring, thus forming a seamless sheath.

The size of slug which can be employed is limited by the capacity of the press. If the cable is a long one, it may become necessary to stop the process while the ram is withdrawn and a new slug inserted. This takes about two minutes, but more serious than the loss of time is the prolonged heating to which the cable insulation is thereby exposed—extrusion of aluminium has to be carried out at temperatures of between 400 deg. and 450 deg. Cent.—and the mechanical weakening of the sheath due to necking caused by the die shrinking slightly as the pressure is released. By using presses of up to 4500 tons capacity, and aluminium slugs of up to 160 kg, one has endeavoured to sheath entire lengths of cable without interruptions, but evidently there are economical and technical limits to such a solution.

The novel principle employed in the present design will become apparent from the accompanying illustration. The extrusion die is



A—Cable.
B—Mandrel.
C—Ring.
D—Die.
E—Sub-frame.
F—Hydraulic ram.
G—Intermediate ram.
H—Die cavity (reservoir).
J—Extrusion cylinder.
K—Extrusion ram.
L—Non-return valve.

Extrusion press and die for the continuous sheathing of cable with aluminium

supported between a hydraulic ram acting vertically upwards and an intermediate extrusion ram acting from above. This intermediate ram operates in a short cylindrical cavity in the die. Through its hollow centre, it communicates with the main extrusion cylinder from which it is separated by a non-return valve.

During the main part of the cycle, metal is extruded by the press ram and flows past the non-return valve and through the intermediate ram into the sheathing die. The die bottoms on the sub-frame, and the intermediate cavity is completely filled with metal. When the slug is coming to an end, water under high pressure is admitted to the space underneath the bottom ram which thus forces the die upwards. The non-return valve closes and disconnects the main from the intermediate cylinder. The main ram may now be raised and a new slug inserted, while the sheathing process continues under the action of the bottom ram, using the metal stored in the die cavity. With the insertion of a new aluminium slug the whole cycle may then be repeated.

Water Supply Congress

The Fifth International Water Supply Congress and Exhibition was held in West Berlin from May 29 to June 3. Some 1300 experts from forty different countries, including 500 from Germany, participated in the meeting, which had been called together by the International Water Supply Association (I.W.S.A.).

The I.W.S.A. was founded in Amsterdam in 1949, and beginning in that year has held technical congresses in Amsterdam, Paris, London, and Brussels, and now Berlin. These congresses have become the principal international forum for the discussion of the world-wide problems of water supply. While the supply of water is in general a local matter, and it is only in a few special cases, e.g., that of the Rhine, that national frontiers are transcended, there is a multiplicity of problems which can only be dealt with advantageously on international level. In certain cases there exists already an international body, for instance the Rhine Commission, for dealing with a particular matter. In other instances, the question is handled by the I.W.S.A. whose technical-scientific committee selected the topics for discussion at the recent congress. One of the main themes of discussion has been the protection of existing resources and the combating of pollution in rivers and lakes. This is a field in which the W.H.O. is also taking an active interest. Another matter which promises to become increasingly important is the de-salting of sea-water. International co-operation and the exchange of views among experts from different countries is of particular importance, since problems connected with water supplies, while outwardly similar, differ greatly in important details in different countries.

Sandvic Research Laboratories

On June 1, King Gustaf VI Adolf of Sweden formally inaugurated the new steel research centre and laboratories of Sandvikens Jernverks AB.

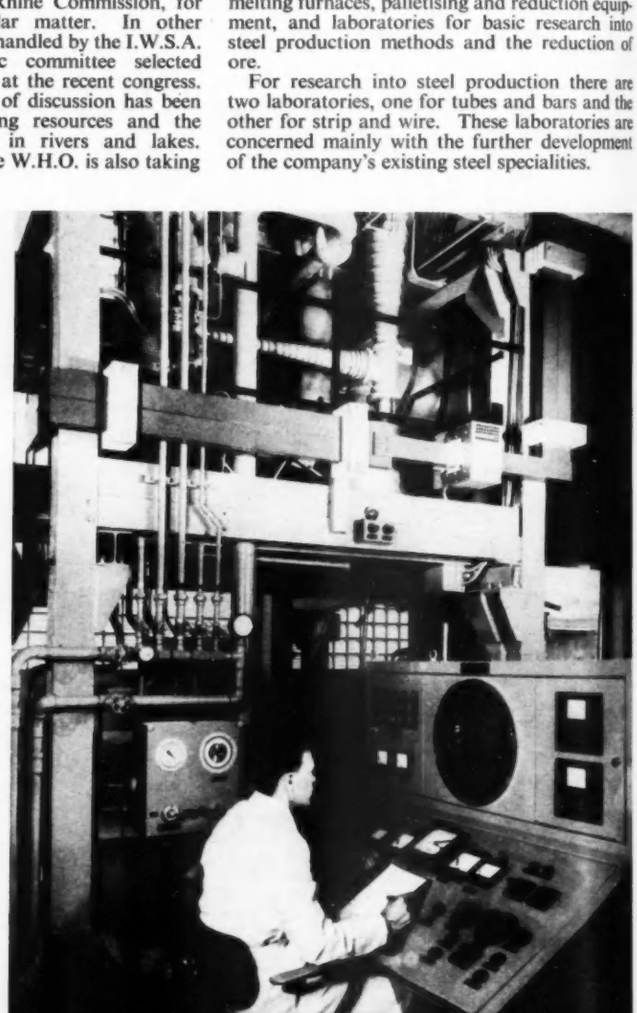
This major extension of the research facilities at the Sandvik Steel Works, 120 miles north of Stockholm, has cost about 7,000,000 Swedish Kronor (£500,000). The company's steel research organisation employs more than 250 people and is stated to be the biggest in Sweden.

For long-term research into metal physics and process metallurgy there are now available two special laboratories.

The physical metallurgy laboratory is housed in a new five-storey main building with a total floor area of about 35,000 square feet. Its equipment includes an electron microscope capable of a magnification of ×200,000, X-ray apparatus, and a high-temperature microscope.

The pilot plant for research into process metallurgy contains heavy equipment such as a high vacuum melting furnace (illustrated) for the production of extremely pure steel, high-frequency melting furnaces, palletising and reduction equipment, and laboratories for basic research into steel production methods and the reduction of ore.

For research into steel production there are two laboratories, one for tubes and bars and the other for strip and wire. These laboratories are concerned mainly with the further development of the company's existing steel specialities.



Instrument panel of high vacuum electric arc furnace, for remelting steel at pressures down to 0·001mm Hg

European Transport

IN its Seventh Annual Report,* the European Conference of Ministers of Transport (E.C.M.T.), which consists of the Ministers of Tranport of the O.E.E.C. countries and Yugoslavia, refers to the tonic effect on transport due to the expansion of business in most member countries in 1960.

Rail Transport.—In terms of ton-kilometres, the transport of goods by rail in the E.C.M.T. countries showed the following trend in the last few years (1953=100) : 1954, 103 ; 1955, 112 ; 1956, 117 ; 1957, 119 ; 1958, 111 ; 1959, 112·5 ; 1960 (provisional figure), 121. After the recession of 1958 and 1959 recovery occurred and gathered momentum in 1960. The average volume of transport expansion in 1960 was similar in the six E.E.C. countries and the seven E.F.T.A. countries (9 to 10 per cent) and also in Yugoslavia. Owing, however to the shrinkage in the volume of transport in the other member countries the aggregate increase was only 7·7 per cent for the E.C.M.T. countries combined.

The decline in passenger transport (about 1 per cent in 1958 and 1959) continued in 1960, but more slowly. An average decline of 0·7 per cent was recorded in the number of passengers and an increase of 0·5 per cent in the number of passenger-kilometres, the figures varying from one country to another. In the main, passenger transport by rail appears to have reached a stable level as the upward trend in business has largely tended to stimulate transport by private car.

Inland Waterway and Sea Transport.—After a 3 per cent decline from 1957 to 1958, inland waterway transport improved by 4 per cent in 1959 and there was a considerable expansion in the tonnage carried in 1960, when it reached a total of 18 per cent. This expansion was still higher on the two main European waterways, the Rhine and the Danube.

Normal Rhine traffic, after fluctuating from 1956 to 1959 between 104·5 and 109·7 million tons, rocketed in 1960 to 130 million tons. This record was due to the combined effect of several factors, i.e. business expansion, the building in early 1960 of transport which had been postponed during the low water period at the end of 1959 and the persistence of conditions particularly favourable to navigation. The figures for Rhine traffic in 1960 are therefore somewhat exceptional.

If the figures for Rhine traffic across the German–Netherlands frontier alone are considered, the 1960 level was 28·3 per cent higher than the previous year ; this figure may even be increased to 30·8 per cent by ignoring the figure for the transport of mineral oil, the expansion of which (12 per cent only) was considerably reduced by the coming on stream of two crude oil pipelines between Rotterdam and Wilhelmshaven and the Cologne area.

Danube traffic also showed a considerable increase in 1960 as compared with the previous year, amounting to 25 per cent on the Austrian reaches of the river and 27 per cent on the Yugoslav stretch. As in the case of the Rhine, this figure is due to the economic expansion and the persistence throughout the year of conditions favourable to navigation.

All the main European seaports have recorded an increase in goods traffic in 1960 : among the northern ports, Rotterdam showed the highest increase (19 per cent), and the southern ports, Genoa (23 per cent) and Trieste (21 per cent).

Road Transport.—The number of motor vehicles in the seventeen member countries, which in previous years had increased regularly at an annual rate of over 10 per cent, continued to advance in 1960. The same applies to fuel consumption, the general rate of increase varying from one country to another between 7 and 20 per cent. Most countries recorded a sharp increase in the volume of road transport of between 5 and 15 per cent on the average, and in some countries even over 20 per cent. International road transport expanded even more, showing sometimes increases of between 15 and 30 per cent and higher in certain cases.

Developments

Railways.—The electrification of the railways, which is now complete in Switzerland and practically so in the Netherlands and Sweden, is under way in Austria, Belgium, France, Germany, Italy and Spain ; 702km of main routes were electrified from October, 1959, to October, 1960, bringing the total length to 20,100km. The main work now in hand is on the following lines : Paris–Strasbourg ; Paris–Marseilles ; Brussels–Paris ; Munich–Würzburg ; Vienna–Venice ; Alcazar–Cordoba ; Genoa–Turin (modernisation of the current system).

Replacement of steam locomotives by diesel traction is continuing. In terms of gross ton kilometres hauled, steam now accounts for only 44·3 per cent as compared with 47·3 per cent for electric and 8·4 per cent for diesel traction.

Motorways.—Among the main motorways completed, the following may be mentioned : Amsterdam – Rotterdam ; Genoa – Milan and Milan–Florence ; the Autoroute du Sud in the Paris area, and the first stretch of the Esterel motor road. Work has advanced on the following : Antwerp–Liége–Aix-la-Chapelle ; Brussels–Namur; Hamburg–Frankfurt; Karlsruhe–Basle; Vienna–Salzburg (one-third completed).

Good progress has also been made on the new direct "crow's flight" link between Germany and Denmark and in the construction of two Alpine tunnels under Mont Blanc and the Great St. Bernard Pass, which have now reached the halfway point.

Inland Waterways.—The report shows the progress made with the large-scale work now being done to extend the network of European waterways, i.e. from the Meuse to the French frontier ; the Moselle to Thionville ; and the Main to Nüremberg. Studies continue of the Rhône–Rhine and the Po–Lake Maggiore links, and the development of the upper Rhine between Basle and Lake Constance.

The "pusher" technique has been examined from its technical and economic aspects ; in the case of waterways which have not yet been modernised or built, provisional standards have been adopted for barges and minimum lock dimensions.

Pipelines.—In 1960, 12,000,000 tons of crude oil were carried into Western Germany by two pipelines linking the Ruhr and Cologne districts with the ports of Wilhelmshaven (9,500,000 tons) and Rotterdam (2,500,000 tons). Two other pipelines for crude oil have been begun : Marseilles–Strasbourg with a possible extension to Karlsruhe ; and Genoa–Aigle (in the canton of Valais in Switzerland).

Policy.—Long-term estimates (up to 1970) of transport demand have been made ; volume, coordination and financing of investment ; financial position of the railways ; standardisation of national regulations in connection with technical norms and road vehicle traffic. Much work was carried out during last year, with regard to the standardisation of weight and dimensions of commercial road vehicles. There has been a considerable reconciliation of conflicting viewpoints, and it has been agreed to introduce uniform standards into international transport which are to be put into force after a transitional period ending on December 31, 1965. Work is also progressing with the standardisation of national road traffic regulations, in order to evolve a "European Highway Code."

This is one of the measures designed to reduce the number of accidents. The question of road safety continues to be of major concern. Continuing the programme launched last year in the course of the Conference, resolutions adopted in 1960 concern the education of road users, measures to counter drunkenness, the issue of driving licences and the maintenance of a central record of traffic convictions. Several countries (Austria, Belgium, France, Germany, Sweden and the United Kingdom) have recently experimented with temporary speed limits, and the effect of these measures is now being analysed.

* "European Conference of Ministers of Transport : Seventh Annual Report." Paris : O.E.E.C. Press and Information Division, 2, rue André-Pascal, Paris (16e). Free on application.

Inspection of Lamp Filaments on a Coiling Machine

In order to ensure the proper operation of a coiling machine for making lamp filaments, and to check the quality of the wire, it is necessary to carry out sampling inspection at a comparatively high rate of about 1 in 30. This has to be carried out before the continuous filament is cut up into lengths, and as it is obviously undesirable to stop the machine, the examination, which involves the use of a microscope, must be carried out on the moving filament. Until the recent introduction of very fast coiling machines this was feasible. With the latest machines special means have had to be developed for artificially arresting the image of the filament for examining it. The Philips Laboratories at Einhoven have devised a method using closed circuit television.*

The filament moves continuously across the field of a microscope with magnification of 100x. It is illuminated for 10 micro-seconds by a manually triggered flash tube. By cutting a suitable hole in the reflector used behind the filament, and placing a screen between the flash tube and the microscope, direct light from the tube is excluded. The microscopic image is observed by a "Vidicon" tube after amplification shown on the screen of a cathode ray tube with thirty seconds afterglow, which gives sufficient brightness for an examination lasting ten to fifteen seconds.

Since the charge pattern on the Vidicon tube decays slowly, scanning can be carried out in the normal time of $^1/_{25}$th second. There is no need for the flash to be synchronised with the scanning beam.

The cathode ray screen is of the kind used in radar and consists of two layers, one fluorescent (blue) and the other phosphorescent (yellow). The first is excited by the electron beam to give an image of short duration which in turn excites the second layer to give an image which persists for some time. In order to avoid dazzle by the blue image, the screen is observed through a yellow filter.

A degree of blur of 0·5mm being acceptable, with a 100x magnification it is possible to observe objects moving at the comparatively high speed of 50cm per second.

European Foundry Industry

For the past seven years, the principal foundry industries of Western Europe have collaborated closely through the European Committee of Foundry Associations, of which the United Kingdom foundry industry—ferrous and non-ferrous—is a member. A recently published tri-lingual brochure† outlines the economic and social contributions made by foundries in eleven affiliated countries, and the work of the Committee which includes among other subjects, training, productivity, market development and technical organisation, health and safety, and important in the present-day context of negotiations affecting the Six and the Seven European institutions.

Strasbourg Refinery

Société de la Raffinerie de Strasbourg has selected P.I.C. Engineering as contractors for their atmospheric distillation unit and gasoline treating unit to be built at the Strasbourg refinery.

McKee Head Wrightson of London, a company jointly owned by Head Wrightson and Arthur G. McKee of U.S.A., will provide process design, basic mechanical design and general supervision services to P.I.C. in connection with this project, under a working arrangement between the two companies.

The unit is designed to process 3,300,000 tons per annum of Hassi-Messaoud and Irak crude oil and is scheduled for completion by early 1963.

* Philips "Technical Review," Vol. 22, 1960–61, No. 7, pages 239–41.

† "The European Foundry Industry." Obtainable from The Council of Iron Foundry Associations Council, 14, Pall Mall, London, S.W.1. Price 6s. post free.

THE AMERICAN SCENE

By Our American Editor

Calibration of Platinum Resistance Thermometers

There is to-day a growing need in all branches of science and technology for temperature measurements of increased accuracy and precision. This is true not only over the usual range of temperatures, but in the more extreme temperature regions as well. Platinum resistance thermometers, which can be used over a wide range of temperatures with great effectiveness, help to fill this need. The International Practical Temperature Scale is defined over the range −182·97 deg. to +630·5 deg. Cent. in terms of a platinum resistance thermometer. The National Bureau of Standards, by calibrating standard platinum resistance thermometers for science and industry, contributes to the accuracy and uniformity of temperature determinations.

THE National Bureau of Standards, of Washington, D.C., through its calibration services, contributes to the accuracy and uniformity of the temperature determinations made with platinum resistance thermometers. Although there are many types of resistance thermometers employing a variety of materials, the Bureau specifies that only thermometers having a four-lead resistor of very pure platinum, hermetically sealed in a protecting tube, be submitted for calibration. These resistance thermometers are made in three general forms (Figs. 1 and 2): long-stem, capsule, and calorimetric thermometers. The sensing element in the long-stem and capsule types consists of a fine helix of platinum wire wound bifilarly on a supporting frame of mica. The winding is supported by notches in the mica frame in such a manner as to leave the wire as strain-free as possible. Near each free end of the coil is attached an additional short platinum lead wire, making the sensing element a four-lead resistor. The coil is protected by enclosure within a gas-filled case.

The capsule thermometer is short about 2in in length, and has a platinum case. The lead wires exit through an airtight glass seal, and the capsule is filled with a mixture of helium with 2 per cent oxygen. As the entire capsule, including the glass seal, is at the temperature being measured, and because glass becomes significantly conducting at high temperatures, this resistance thermometer is not normally used above 300 deg. Cent.

The stem resistance thermometer is usually about 18in long, although the resistance coil is quite small. The short platinum leads of the resistor are attached to four gold extension wires, and the entire assembly is enclosed within a glass cylinder containing dry nitrogen and 2 per cent oxygen. Because of the length of this device, the point where the wires exit through the case is at room temperature, and stem thermometers are often used up to 500 deg. Cent. if encased in glass and up to 630 deg. Cent. if enclosed in quartz.

The third type of platinum resistance thermometer, used in calorimetric measurements, has a coil wound on a flat strip of mica which is encased within a thin metal sheath. The case is filled with dry air. This construction has the advantage of rapid thermal response, which is important in calorimetric determinations. The capsule resistance thermometers are calibrated at temperatures as low as −263 deg. Cent. or 10 deg. K but, because of the electrical conductivity of the glass at high temperature, they are usually not calibrated at the sulphur point. Thermometers of the stem type are calibrated at the boiling points of oxygen (−182·97 deg. Cent.), water, and sulphur (444·6 deg. Cent.), and at the triple point of water. Those of the calorimetric type are calibrated at the triple point, the steam point, and near 50 deg. Cent. The capsule and stem thermometers are annealed before calibration by being placed in the re-entrant wells of the sulphur boiler for four hours.

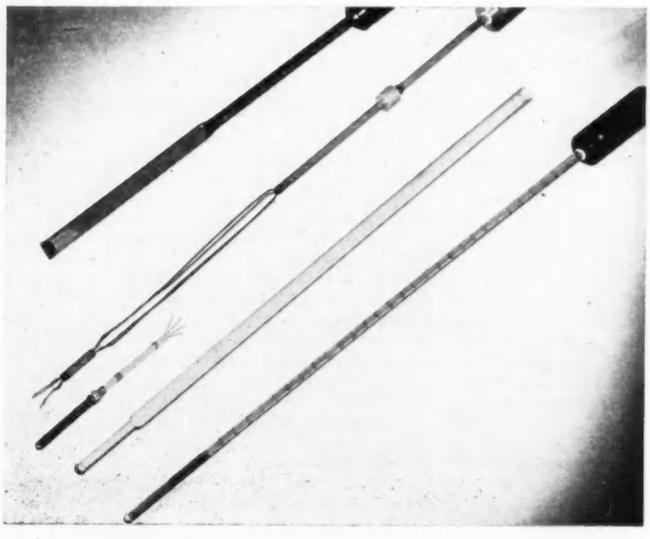


Fig. 1—Range of platinum resistance thermometers, with metal-encased calorimetry unit at upper left, short capsule type with its glass protection tube in the centre and a stem-type thermometer at the bottom

Resistance Measurement

The resistance of the thermometer being calibrated is measured with a Mueller bridge, Fig. 3. Readings are taken to the nearest 10 micro-ohms, with a current of 2mA flowing in the thermometer. In most cases, the heating effect of this current can be ignored if the thermometer is used with this same current. However, if the thermometer is to be used under conditions where the thermal contact is poor or variable, errors which might arise from the heating effect

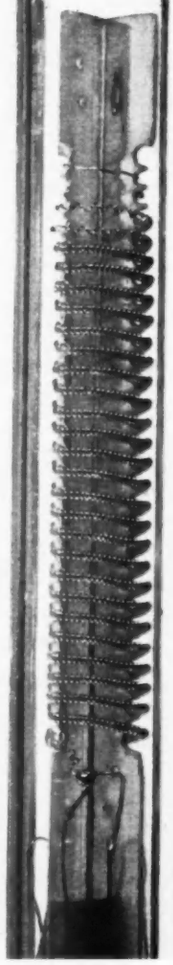
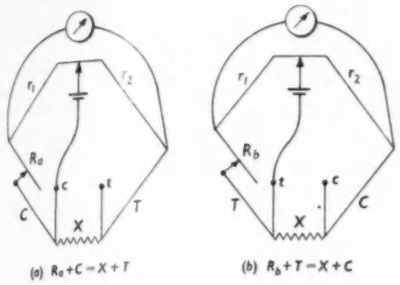


Fig. 2—Close-up view of the coil of a platinum resistance thermometer

can be minimised if all resistance readings are taken with both 2mA and 5mA flowing in the thermometer, and the resistance at zero current is found by extrapolation. To eliminate the resistance of the lead wires attached to the platinum resistor, readings are made with two combinations of bridge-lead connections. The resistance of the coil alone is then the average of the two readings.



ADDING THE EQUATIONS YIELDS $X=\frac{R_a-R_b}{2}$

Fig. 3—Diagram of the circuits used to eliminate the effect of lead resistance in thermometer calibration

Low-Temperature Calibration

Over the range of 10 deg. to 90 deg. K, capsule-type resistance thermometers are calibrated in a hydrogen bath against one of the standard resistance thermometers maintained by the Bureau. Both the test and standard thermometers are inserted into a copper block, and the necessary connections are made, Fig. 4. This aggregate is then placed within the cryostat. The system is sealed from the atmosphere by soldering an airtight canister to the stationary cover with Woods metal. The temperature within the cryostat is controlled at temperatures below 20 deg. K by adjusting the pressure on the liquid hydrogen refrigerant within the cryostat. At temperatures above 20 deg. K, the temperature is controlled by electrically heating the block to achieve the desired temperature and then heating the shield to maintain this temperature. A control system, actuated by a multiple-junction thermocouple between the copper block and the shield, maintains the temperature within narrow limits. After thermal equilibrium is achieved at each calibration temperature, several simultaneous resistance readings are taken on each thermometer and the standard.

Fig. 4—Cryostat used in calibrating capsule-type thermometers at very low temperatures, with copper block at lower right and metal Dewar immediately above. A second Dewar is shown in the background

A second cryostat is used for the calibration of both capsule and stem resistance thermometers at the oxygen point (−182·97 deg. Cent.). Once again, a comparison is made with a standard resistance thermometer. Because the thermometers are inserted in long re-entrant wells, a lead-wire assembly must be attached to capsule thermometers, and a glass protection tube is slipped over both the thermometer and lead wires. Liquid nitrogen is used to cool the cryostat, and a heating coil, controlled automatically as in the hydrogen bath, is used to maintain the temperature at the oxygen point. Several readings are taken for each thermometer at the oxygen point.

Fig. 5—Triple point calibration of resistance thermometer, with water-ice interface surrounding the re-entrant well of the cell

Triple Point Calibration

Although the triple point of water (0·01 deg. Cent.) was not adopted as a defining fixed point on the International Practical Temperature Scale until 1960, the Bureau has been using triple point cells in calibration activities for many years. The cell consists of a sealed glass cylinder nearly filled with pure, air-free water, Fig. 5. A re-entrant well is provided for the insertion of a thermometer. In use, the cell is cooled by immersion in an ice bath, and a mantle of ice is formed around the re-entrant well with dry ice. After a sufficient mantle has formed it is freed from the glass by slight warming from within the well, to provide an immediately-adjacent water-ice interface. The thermometer is then inserted into the well, using an aluminium bushing to obtain good thermal contact. Resistance readings are then taken after equilibrium is achieved. To check on the stability of a thermometer during calibration, the resistance at the triple point is determined before and after measurement at any of the other fixed points.

Steam and Sulphur Point Calibration

Special boilers, operating in a closed system in which the pressure can be closely regulated, are used to reproduce the steam (100 deg. Cent.) and sulphur (444·6 deg. Cent.) points. Helium gas is employed to transmit the pressure to a precision manometer. The boilers are cylindrical, with re-entrant wells extending from the top into the vapour region. The water boiler was constructed of copper, heavily tinned on the inside to prevent contamination, and the sulphur boiler was made of "2S" aluminium alloy. At the bottom of each boiler is a re-entrant dome, inside which is placed an electric heater, Tangent to the dome, and within the boiler. are positioned vertical silver or aluminium wires which prevent explosive boiling. Radiation shields are placed within the boilers to isolate the re-entrant wells from the boiler walls and heating zone. The vapours are condensed at the top of the boiler by means of a water-cooled jacket. The level of the helium-vapour interface, which must be known for the determination of pressure, is measured with thermocouples placed within the walls of the condenser.

The water boiler reaches thermal equilibrium quite rapidly, but experience has shown that temperature changes occur within the sulphur boiler for some time. Therefore, calibrations are not started until the sulphur has boiled for at least ten days. With each boiler, several resistance readings are taken for each thermometer after equilibrium is reached in the re-entrant wells.

The Bureau also calibrates calorimetric resistance thermometers. This calibration is accomplished by determining the resistance at the ice and steam points, and at a third point near 50 deg. Cent. A stirred water bath, in which the test thermometer is compared with a standard thermometer, is used for the latter point. Also, the resistance of platinum wires such as are used in thermocouple construction, is determined at the triple and steam points. The resistance at 0 deg. Cent. is then computed, and the ratio of the resistances at zero and 100 deg. Cent. is determined. This ratio must exceed 1·3920 to meet the specifications of the International Practical Temperature Scale.

Research

Research is being conducted in several areas to extend the accuracy and range of platinum resistance thermometers. A thermometer has been constructed, consisting of platinum threaded through holes drilled in synthetic sapphire discs, and has been found to drift less than 0·001 deg. per hour at 1000 deg. Cent., Fig. 6. The further development of resistance thermometers for use at high temperatures may eventually lead to the extension of the defining range of these thermometers on the International Practical Temperature Scale to 1063 deg. Cent. The present limit is 630·5 deg. Cent.

Efforts are being made to put the calibration procedure on a more automatic basis. Read-out devices are being incorporated to permit automatic recording of all basic data which will facilitate communication with the computer. Plans have been made to permit the oxygen bath to be connected to the precision manometer which will provide, directly, a defining fixed point temperature of −182·97 deg. Cent. Plans are also being made to construct an apparatus for the calibration of resistance thermometers at the zinc point of 419·505 deg. Cent. This temperature is more reproducible than the sulphur point and has been accepted as an alternative to the sulphur point in the 1960 text of the I.P.T.S.

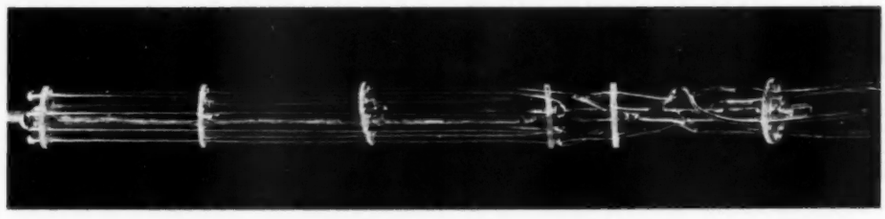


Fig. 6—Special high-temperature platinum resistance thermometer with disc supports made of synthetic sapphire

THE AMERICAN SCENE *(Continued)*

Application of Ultrasonics to Grinding

AN interesting application of ultrasonics to machine shop grinding practice has been introduced by the Cavitron Equipment Corporation, of Long Island City, New York. The build-up of metal particles on the surface of a grinding wheel can be virtually eliminated by this application of ultrasonic principles, called "Ever-Grind." Essentially, the equipment consists of a transducer source of intense ultrasonic vibrations placed in close proximity to (actually within a few thousandths of an inch of) the cutting surface of the grinding wheel; a water-base coolant is pumped through the transducer into the space between the output end of the transducer and the wheel. The physical conditions and the design of the output end of the transducer are critically important for the successful operation of the method. Transducer vibrations in the 20,000 c/s range are transmitted by the coolant to the wheel surface, where the output end of the vibrator causes an effective loading-preventive action. As a result of this action, minute metal particles that would normally tend to cling to the wheel and become embedded are removed.

Although the transducer can be positioned radially at any angle, it is usually placed vertically at the top of the wheel. Transducer tools for wheels up to 2in wide are available at present. A close-up view of the transducer mounted at the top of the wheel of a reciprocating surface-grinding machine is shown in Fig. 1. The application of the process is not limited to surface-grinding machines, as the set-up can be used wherever the wheel is accessible.

In ordinary use, grinding wheels begin picking up small pieces of metal from the first revolution in contact with the work. As operation continues, these particles build up on the wheel and weld to each other, causing loading. When loading becomes excessive, the cutting action ceases and the increase in friction between the work and the wheel burns the work. At this point the operator must stop grinding and dress the wheel. The "Ever-Grind" process does not clean the wheel, since in the first revolution very fine particles of metal do get between the abrasive grains. What the process does is to prevent any build-up of metal on these small nuclei particles that have entered the wheel. Thus loading is prevented to the extent that it has little, if any, effect on the grinding process.

Essentially, the wheel is maintained in a free-cutting state for a longer period of time. Although build-up is held to a minimum, abrasive grains in the wheel do eventually become dull and the wheel ceases to cut. When this condition is reached, the wheel is said to be at the glaze point and has had ultimate use before redressing. Since particle build-up does not occur and the abrasive grains remain free-cutting for an extended period of time, wheel life is correspondingly lengthened. In addition, the wear of the wheel during grinding is reduced to a minimum. This can be an important consideration in using the process for "automated" grinding set-ups. In some cases wear has been one-tenth of that in similar grinding operations performed without the use of the ultrasonic equipment.

At the Lycoming Division of the Avco Corporation, the ultrasonic equipment was installed on an Arter rotary surface-grinding machine. In one operation, the process was used to grind an overhanging flange surface on a forged nitriding-steel part having a hardness of 67·5 to 70·5 Rockwell A. It had normally been difficult to hold the surface parallel to within the 0·0005in tolerance required. For roughing, a 15in diameter wheel 1½in wide was employed at a wheel speed of 6000 surface feet per minute. The work speed was 280 surface feet per minute, the cross-feed was 2in per minute, and the automatic downfeed was 0·0005in per pass. The total stock removal was 0·012in per part over the surface of the 1⅜in wide by 14½in diameter flange. With the process, floor-to-floor time was cut from thirty to seventeen minutes and dressing was not required after a run which totalled eleven pieces. Without the process, the wheel had to be dressed after every three pieces. A later finishing operation on the same part showed approximately the same results in floor-to-floor time, but wheel dressing, which was normally required after every piece, was not necessary for an entire run of twenty pieces.

Maintaining a free-cutting wheel permits the grinding of thin-gauge work with little warpage, as the grinding force required is relatively small and the heat developed due to friction is low.

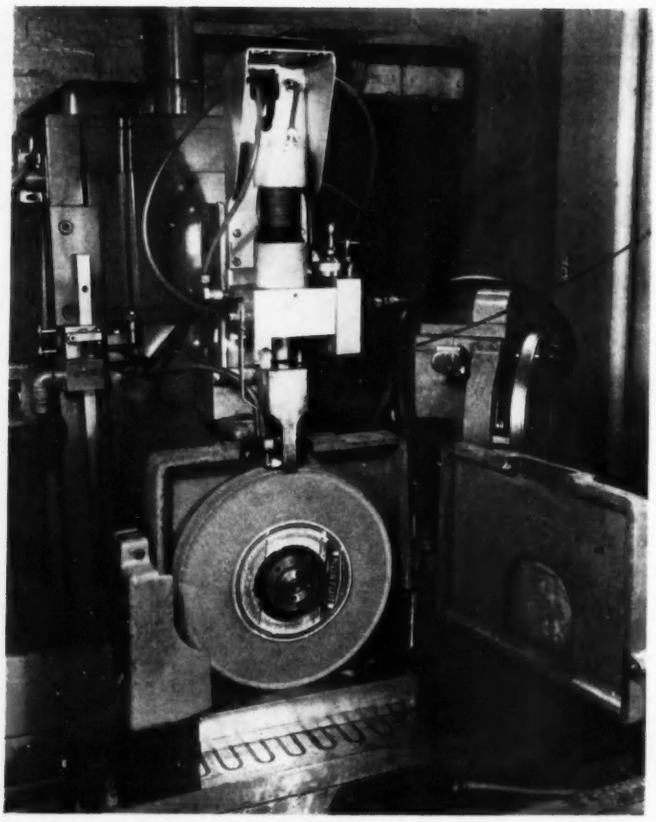


Fig. 1—Cavitron "Ever-Grind" ultrasonic unit mounted on a surface grinding machine head, with magnetostrictive transducer at the top

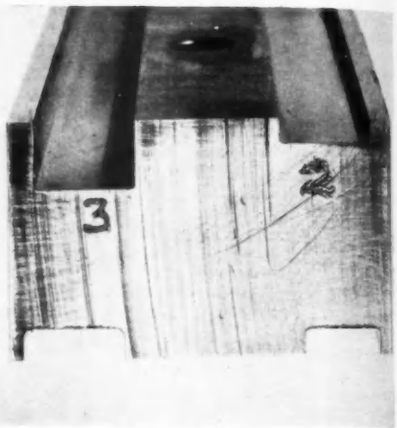


Fig. 2—Comparison of grooves plunge-ground into stainless steel: No. 2 without and No. 3 with the application of "Ever-Grind"

At the works of a large computer manufacturer, a ⅜in by 2in boss was required to be ground on a 0·040in thick formed steel part. The dimensional tolerance was plus or minus 0·001in, and a smooth finish was necessary. Unless the wheel were free-cutting, this fragile part would chatter and the accuracy and finish would be poor. With the ultrasonic process, 308 parts were ground in less than eight hours on one wheel dressing, and a 12 micro-inch finish (average) was maintained.

Surface finish is significantly improved by the process. In one application at the Grumman Aircraft Engineering Corporation, a type 304 stainless steel 12in diameter part was required to have an 8 micro-inch finish. The operation was performed on a reciprocating surface-grinding machine equipped for the ultrasonic process. In operation, a downfeed of 0·0005in to 0·0007in, a cross-feed of approximately 0·015in, and a table speed of 60ft per minute were employed. The overall stock removal was 0·004in. The wheel was 12in in diameter and 1in wide, and was in a clean condition after grinding. No loading or burning occurred, and a 4 micro-inch surface finish was achieved.

If loading is prevented, soft metals such as brass, aluminium, and magnesium can be ground with harder-grade wheels. As a result the wheel inventories required in some cases can be reduced. Difficult-to-grind metals are also reported to be ground more readily. Of the two grooves plunge-ground in the type 303 stainless steel test part seen in Fig. 2, the shallower one was ground in the regular manner to a depth of 0·127in. At this point the wheel was loaded and a 60 micro-inch finish was obtained. The deeper groove was plunge-ground 0·337in, using the ultrasonic attachment under the same grinding conditions. A 35 micro-inch finish resulted, with the wheel remaining essentially clean. Dressing before re-use was not required. In another test on type 303 stainless steel, made under identical conditions, regular grinding removed 0·057in, leaving a 35 micro-inch finish, and wore the wheel 0·009in. With "Ever-Grind," 0·108in was removed, an 8 micro-inch finish was obtained, and the wheel wore only 0·0015in.

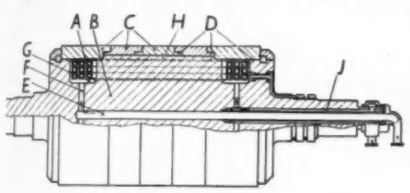
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRICAL ENGINEERING

869,174. April 28, 1959.—Cooling Systems for Electric Machine Rotors, Zavody V. I. Lenina Plzen, Narodni Podnik, Plzen, Czechoslovakia.

In endeavours to find a more effective method of cooling the rotor windings of electric machines, cooling by means of a cooling liquid has been considered. Difficulties in the realisation of this idea were met, however, because of the requirement that the liquid, which flows through the rotor winding and through the rotor body, must be prevented from escaping into the other spaces of the machine. It is therefore the object of the present invention to find a satisfactory solution for this problem. The invention provides a rotor for electric machines having a winding cooled by direct contact with a fluid cooling medium, characterised in that the winding and parts of the rotor where the winding is located are enclosed by non-magnetic rings, pressed one against the other by their adjacent ends provided with shoulders with interposed high-pressure seals to prevent any escape of the cooling medium into the stator space of the machine. In order to increase the cooling effect at the outer surface of the rotor, where it faces the surrounding cylinder of non-magnetic material, it is advantageous to provide longitudinal grooves for the passage of the cooling medium at this outer surface and/or on the surface of the wedges which close the winding slots. In order to reduce losses due to pulsation in



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synchronous machines, occurring at synchronous speeds, the non-magnetic cylinder may be provided with longitudinal corrugations on the surface. As shown in the drawing, a rotor winding *A*, consisting of hollow or profiled conductors, is accommodated in slots of the rotor body *B*. The whole winding *A* and also the core of the rotor body *B* are surrounded by a cylinder of non-magnetic material, which cylinder consists of a series of inter-fitting rings *C* which are sealed by means of high-pressure seals *D* so as to prevent the cooling medium, which is a liquid, from escaping from the rotor into the space taken by the stator of the machine. The liquid cooling medium is supplied to the rotor through the innermost part of the axial bore *E* of the rotor body *B* from where the liquid passes through channels *F* into a space *G* and then flows through the hollow conductors and, if provided, through the grooves in the surface of the rotor body and the wedges *H* into the space *G* at the other end of the rotor. The liquid then proceeds through radial channels into the outer part of the axial bore *J* from where it is discharged out of the machine. This invention may also be used for gaseous cooling media.—*May* 31, 1961.

MAGNETS

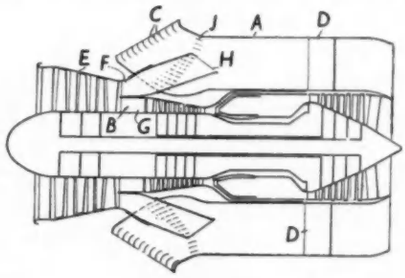
869,074. July 25, 1957.—Magnetic Circuits, Philips Electrical Industries, Ltd., Spencer House, South Place, Finsbury, London, E.C.2.

This invention relates to magnetic circuits having a variable reluctance including one or more cores of magnetic material and a rotary "soft" magnetic part incorporated in the circuit. The object of the invention is to permit a very efficient control of the reluctance. The magnetic circuit is characterised by the feature that the rotary part consists of a sintered ceramic magnetically anisotropic "soft" magnetic material, the magnetic particles of which are so pre-oriented during manufacture that the permeabilities of the part in two mutually perpendicular directions at right angles to the axis of rotation are greatly different. The invention may be used in devices having a closed or substantially closed magnetic circuit, so that the inductance or the mutual inductance of windings on the magnetic circuit is variable within wide limits. As an alternative, it may be used in electromechanical transducers, for example in pickups. Among examples described in the specification are a means of controlling the coupling factor between two coils, a pickup, and a dynamo-electric machine. The latter comprises three "soft" magnetic cores jointly enclosing a cylinder of anisotropic "soft" magnetic material of the kind herein referred to having a high permeability in the direction of the axis and in the direction at right angles thereto, but a low permeability in the third direction at right angles thereto. With a permanent magnet in series with the cylinder, rotation of the cylinder will produce a three-phase current through windings on the cores. Conversely, even when omiting the permanent magnet, a three-phase current through the core windings will cause the cylinder to rotate similarly to a synchronous motor.—*May* 31, 1961.

AIRCRAFT ENGINES

869,587. February 12, 1960.—Jet Lift Gas Turbine Engines, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor : Alan Arnold Griffith.*)

This invention relates to gas turbine jet lift engines. The term "lift engines" is to be understood to mean gas turbine engines which are adapted to provide vertical lift for an aircraft independently of the aerodynamic lift produced by forward flight. The engine is disposed in a conduit in the form of a cylindrical casing which is open at each end and which has a larger internal diameter than the greatest external diameter of the engine. The engine and the casing are arranged coaxially with an annular passage *A* defined between them. One end, referred to as the inlet, of the casing is disposed adjacent to the inlet to the compressor *B*, and is flared outwardly, as shown. The inlet has a number of guide vanes *C* which prevent or substantially reduce swirling of air entering the passage. Struts *D*, which connect the engine and the casing rigidly together, have an aerofoil cross-section. The compressor casing *E*, which extends between the L.P. and H.P. portions of the compressor,



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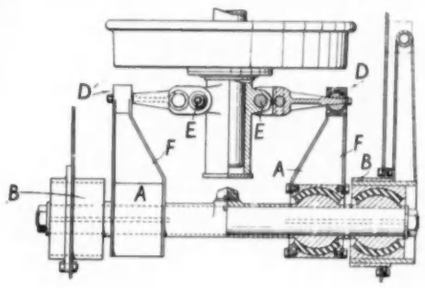
is divided into two separate annular arrays of channels or ducts *F* and *G*, each duct *F* communicating with the passage *A* through a pipe or transfer tube *H* whilst each duct *G* is in direct communication with the H.P. portion of the compressor. Each transfer tube *H* and its associated duct is shaped so that it maintains a uniform cross-sectional area throughout its overall length in order to prevent a loss of pressure occurring in air passing therethrough. The transfer tubes have their outlets directed towards the downstream end of the engine. The outlet ends of the transfer tubes are spaced apart to allow ambient air to flow through the passage *A* in a downstream direction relative to the direction of flow of working fluid through the engine. A further series of guide vanes *J* in the passage *A* downstream of the guide vanes *C* are arranged to obviate any swirling in the air passing into the straight portion of the casing from the flared inlet, whereby smooth linear flow is produced in the passage. When the engine is in use, ambient air enters the L.P. portion of the compressor, is compressed and a proportion of it, say 40 per cent passes into the H.P. portion of the compressor where it is further compressed. The compressed air then passes into the combustion equipment of the engine where it mixes with fuel to form a combustible mixture, the products of combustion passing through the turbine to drive the compressors and provide a propulsive thrust as they exhaust to atmosphere. The remaining proportion of the air, passing from the L.P. portion of the compressor passes through the transfer tubes *H* and is discharged into the annular passage *A*, and since such air has a higher velocity and pressure than ambient air with which the passage is in direct communication, an ejector effect will be produced at the outlets of the transfer tubes. The ejector effect causes a pressure drop immediately upstream of the outlets of the transfer tubes whereby ambient air is drawn into the passage, the velocity of the air being increased by the ejector effect. The pressure in the passage, downstream of the outlets of the tubes, is substantially greater than that of the ambient air. As a result, the propulsive thrust is increased without substantial increase of the fuel consumption, and, at the same time, silencing of the exhaust gases issuing from the engine is effected. The silencing effect is brought about by the annulus of air issuing from the passage which completely surrounds the stream of exhaust gases issuing from the engine. This annulus of air has a greater velocity than that of the ambient air, whereby the initial velocity step between the exhaust gases and ambient air is reduced, with consequent reduction of turubulence.—*May* 31, 1961.

RAILWAY VEHICLES

869,345. May 30, 1957.—Railway Vehicle Wheel Supports, Metalastik, Ltd., Evington Valley Road, Leicester. (*Inventor : Archie John Hirst.*)

This invention concerns wheel supports for lightweight express trains in which each wheel is independently supported from the vehicle frame. Referring to the drawing : the wheel supported from the frame of the vehicle, is mounted on an axle in a housing supported from the vehicle frame. Rising and falling movement of the wheel is allowed for by the rubber bushes of hinges *A*, *B* which are deformed in torsion. The pair of hinges allow a large vertical wheel movement without subjecting the rubber



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bushes to excessive twist. Axial movement of the wheel is taken up by torsion of the rubber bushes of hinges, *D* and the bushes of the hinges *E*. As the train goes round a curve the axle is canted in a horizontal plane with a consequent longitudinal movement of the axle. This movement is taken up by horizontal movement of the swinging arms *F* (which is permitted by torsion of the bushes of hinges *A*) in combination with torsion of the bushes of hinges *D* and of hinges *E*. It will be appreciated therefore that the support allows limited universal movement of the axle with preselected control characteristics arising from deformation of the several rubber bushes. The construction of the support is described in detail in the specification and another practical application is described with reference to drawings.—*May* 31, 1961.

ELECTRONICS

869,123. October 23, 1957.—Deflection Systems for Cathode Ray Tubes, Philco Corporation, Tioga and C Streets, Philadelphia, Pennsylvania, United States of America.

This invention relates to deflection systems for cathode ray tubes, and more particularly to improvement of linearity in such systems. In horizontal deflection systems of the type commonly employed in television receivers, horizontal deflection current is supplied to the coils of the yoke by the co-operative functioning of a driver tube, an output transformer, and a damper diode. While it is desired to provide substantial linearity of the deflection current in the horizontal coils, in the absence of some additional provision toward that end the deflection current tends to be non-linear during the scan intervals. More particularly, the deflection current waveform tends to be exponential rather than linear during each scan interval, its slope being relatively larger at the beginning and relatively smaller at the end of each such interval. This tends to make the line scanning motion

of the electron beam too fast at the beginning and too slow at the end of each line scan for best picture proportion. The object of the present invention is to provide a deflection system improved in this respect. In existing systems, during successive operating cycles voltage pulses are produced across the windings of the output transformer. This invention is based upon the concept of utilising these pulses to develop a linearity correction voltage. In carrying the invention into effect voltage pulses are derived from the output transformer and are converted into a corrective voltage which is used to modify the damper current so as to effect the desired linearity correction. In the preferred embodiment, an auxiliary winding is provided on the output transformer to derive the voltage pulses, and these pulses are applied to a circuit which includes an inductor and a resistor connected in series, the resistor also being in circuit with the damper diode. The inductor integrates the voltage pulses into a current of desired waveform, which flows through the resistor and produces the corrective voltage. The latter effects the modification of the damper current necessary to achieve substantial linearity of the deflection current.—*May* 31, 1961.

SHIPS

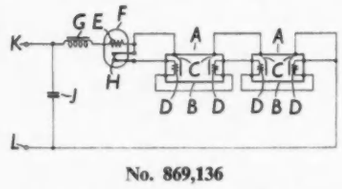
869,352. April 21, 1959.—MARINE VESSELS, George Brown and Co. (Marine), Ltd., and John George Brown, both of Garvel Shipyard, Greenock, Renfrewshire, Scotland.

The invention has for its object to provide improvements whereby vessels can be on-loaded and off-loaded with motor vehicles or heavy machinery without the use of cranes, derricks or ramps irrespective of the height of the vessel relative to the quay due to the state of the tide. The vessel is provided with a series of fingers that can be extended outboards to form a platform somewhat above deck level. Cargo can be raised from the quay by a fork-lift truck, deposited on the fingers when they are in their outboard position and then removed from the fingers by a second fork-lift truck on the deck, the off-loading being effected in the reverse order. The fingers are preferably pivotally mounted so that they can be turned when not required into a substantially vertical stowing position. The fingers are preferably of channel section fitted with cushions of rubber which project above the channel to take the weight of the cargo. According to another embodiment of the invention the fingers may be movable as a unit so that they can be either mounted on the deck to extend over the quay or, when the tide is such that the deck of the vessel is below the level of the quay, the unit can be deposited on the quay to extend over the deck. —*May* 31, 1961.

ELECTRIC LIGHTING

869,136. December 3, 1956.—OPERATING CIRCUITS FOR LOW-PRESSURE ELECTRIC DISCHARGE LAMPS, Associated Electrical Industries, Ltd., 33, Grosvenor Place, London, S.W.1. (*Inventors: Maurice George Clark and Herbert Lawrence Privett.*)

In accordance with one commonly used circuit arrangement for operating from an a.c. supply a number of electric discharge lamps in series, heating current is fed to the electrodes through an inductive ballast common to all the lamps and a number of thermally responsive switching devices, each of which is arranged for controlling the heating circuit of a different lamp. Although the above arrangement has proved generally satisfactory it has the disadvantage that each lamp requires a thermally responsive switching device for its control. It is therefore an object of this invention to provide an arrangement in which one such device alone serves for controlling a number of lamps to be operated in series. The accompanying circuit illustrates one embodiment of



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the invention. There are shown a pair of fluorescent lamps *A* each comprising a gas and/or vapour-filled envelope *B* in which spaced electrodes *C* define an arc discharge gap. The electrodes become electron-emissive when heated to a predetermined temperature by the passage of heating current through filamentary heaters *D*. The lamps are connected in series to define an arc discharge circuit which is connected in a lamp supply circuit comprising a heater *E* of a thermally responsive switching device *F*, such as a bi-metal device for example, and an inductive ballast *G*. The electrode heaters are connected in series with each other and with normally closed contacts *H* of the switching device in a branch circuit directly connected across the lamps. A capacitor *J* is connected across the lamp supply circuit and serves to improve the power factor of the circuit. Since the a.c. supply voltage applied to the terminals *K* and *L* when it is required to start the lamps would be insufficient to initiate a discharge the electrodes *C* are preheated to their electron emitting temperature by the flow of current in the lamp supply circuit including the ballast *G* and the heater *E* and in the branch circuit comprising normally-closed contacts *H* and the electrode heaters *D*. The thermally responsive switching device *F* is so adjusted that the bi-metal strip or other element responsive to the heat produced by the heater *E* opens the switch contacts *H* when the electrodes attain their electron emitting temperature or shortly thereafter. The gas and/or vapour fillings of the lamps are thus at least partially ionised when the contacts open to disconnect the branch circuit and the resulting voltage across the lamps is then sufficient to start the lamps. During operation of the lamps *A* the arc discharge current flowing through the heater *E* maintains the switching device *F* operated. The inductive ballast *G* not only serves for controlling the arc discharge current but also serves to limit the heating current for the electrode heaters *D*. If desired an impedance may be included in the branch circuit further to limit the preheating current.—*May* 31, 1961.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

METHODS OF TESTING WATER USED IN INDUSTRY

Addendum No. 1 to British Standard 2690. Price 6s. This addendum to B.S.2690 deals specifically with the analysis of high purity water, a subject of growing importance and interest. Tests of a more specialised nature or of limited application are not included. The addendum describes tests for determining solids content, carbon dioxide, dissolved silica, total iron and dissolved oxygen in high purity water. These tests are particularly applicable to steam condensate and the addendum can thus be used in conjunction with the recently published B.S. 3285, "Methods of sampling superheated steam from steam generating units."

LENGTH BARS AND THEIR ACCESSORIES

No. 1790 : 1961. Price 10s. The new edition of this specification includes a new calibration grade of bar and a refined screwed connection developed as a result of research work carried out at the National Physical Laboratory. By employing the refined connection, bars may be built into a combination without any appreciable loss of overall inherent accuracy, since it reduces the change in length of such a combination, arising from stresses set up at each joint during hand assembly, to about 1 micro inch (0·000001in) per joint. This enables the building up of inspection bar combinations by screwed connections.

The requirements specified for the four grades of accuracy, viz. reference, calibration, inspection and workshop, have been brought up to date to take advantage of the fact that modern end measuring machines are now provided with universally adjustable supports. The requirements for accessories have been rationalised by the standardisation of one type only.

TUBULAR HEAT EXCHANGERS FOR GENERAL PURPOSES

No. 3274 : 1960. Price 20s. This much-needed British Standard specifies minimum requirements and gives guidance for the mechanical design and construction of shell-and-tube heat exchangers, a specialised form of pressure vessel widely used in industry for such purposes as heating, cooling, evaporating and chemical reaction. Information supplied by the Tubular Heat Exchanger Manufacturers' Association (T.E.M.A.) and the American Society of Mechanical Engineers has been used in the preparation of the standard and the recommendations of B.S.2041 (Tubular heat exchangers for use in the petroleum industry) have been taken into account wherever applicable. The standard covers cylindrical shell and plain tube heat exchangers for general applications within size ranges of 6in to 42in for nominal shell diameters, of 6ft to 16ft for tube lengths and of ¼in to 1¼in for tube diameters. The following types of heat exchanger are included : fixed tube plate (non-removable tube bundle), "U"-tube (removable tube bundle) and floating head (removable tube bundle). Because a wide range of heat exchangers exists, more sizes have been listed than desirable in a standard. Industry is asked to encourage the use of those sizes asterisked as being preferred so that eventually it should be possible to cut out the other sizes.

Catalogues and Brochures

W. G. PYE AND CO., Ltd., Granta Works, York Street, Cambridge.—Illustrated brochure describing the Pye argon chromatograph and giving details of techniques recently developed in the field of chromatographic analysis.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., Electronic Apparatus Division, Carholme Road, Lincoln.—Leaflet giving advance information on germanium gold-bonded diodes for low-power rectification in computers, instruments, data-processing equipment and similar apparatus.

SOLARTRON ELECTRONIC GROUP, Victoria Road, Farnborough, Hants.—Brochure, with illustrations in colour, entitled "New Things under the Sun," and forming a review of the group's activities. In covering its wide field, the text pays particular attention to the uses and potentialities of electronics in industry. This is further emphasised by a table showing how six classes of Solartron products are employed in six major departments of industrial and commercial life.

LANCASHIRE DYNAMO ELECTRONIC PRODUCTS, Ltd., Rugeley, Staffordshire.—"Control for Industry," a profusely illustrated publication showing with the help of annotated block diagrams and photographs of the apparatus concerned, how feedback control systems are applied to twelve industrial processes. In this section the operation of a continuous impregnating and calendering line for tyre fabric form the subject of a folding plate. Subsequent pages detail the activities of the company's various divisions.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, June 23.—SOUTHAMPTON BRANCH : Day visit to the G.E.C. Research Laboratories, Wembley, 8.30 a.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., to Sun., July 5 *to* 9.—1961 Convention : Christ Church, The University, Oxford, "Radio Techniques and Space Research."

COMBUSTION ENGINEERING ASSOCIATION

Tues., June 27.—NORTH WESTERN REGION : Engineers' Club, Albert Square, Manchester, "Shortcomings in Present Day Equipment," M. W. Thring, 2.30 p.m.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Tues. to Thurs., July 11 *to* 13.—Open Days at the Building Research Station, Garston, Watford, Herts.

INSTITUTE OF MECHANICAL ENGINEERS

Sat., June 24.—SOUTHERN BRANCH : Visit to Brighton Corporation Water Department, Church Street, Brighton, and to Mile Oak Pumping Station, 2.15 p.m.

NATIONAL PHYSICAL SOCIETY

Mon. to Wed., June 26 *to* 28.—National Physical Laboratory, Teddington, Middlesex, Three-day Conference on "The Control of Noise."

Advanced Engineering Courses

Current Practice in Fuel Efficiency. NATIONAL INDUSTRIAL FUEL EFFICIENCY SERVICE, SOUTH WESTERN AREA, Ailsa House, 181, King's Road, Reading. Eighth annual refresher course to be held at The Clarendon Laboratory, Oxford, from September 25 to 29. The course covers a wide range of subjects and presents an opportunity for works managers, works and plant engineers, and technical staff of industrial, municipal and public undertakings to acquire up-to-date information on developments and research into the more efficient use of fuels, plant and processing. Fee, covering course, accommodation and meals, £16 16s.

Statistical Quality Control and Acceptance Sampling. THE COLLEGE OF ADVANCED TECHNOLOGY, Birmingham. A full-time course of three weeks' duration commencing Monday, September 11. The course is primarily intended as an introduction to the subject, but nevertheless provides the basic training necessary for quality control engineers. The first fortnight will be spent in covering the general principles and procedures of quality control. The final week will be devoted to lectures by specialists from industry, and to visiting the works of firms employing quality control, where members of the course will be able to see the practical application of quality control methods, and discuss the techniques and associated problems.

BOROUGH POLYTECHNIC, Borough Road, London, S.E.1. **Modern Developments in Non-destructive Testing of Metals.** A course of six lectures, given by specialists from industry on consecutive Wednesday evenings at 7 p.m., commencing October 4. Fee 10s. Type of student : metallurgists, engineers and others interested in this field.

Refractories, their Manufacture, Properties and Uses. A course of ten lectures, given by L. R. Barrett, A.R.I.C., M.Inst.F., F.Inst.Ceram., on consecutive Friday evenings at 7 p.m. commencing October 6. Fee £1. Type of student : metallurgists, chemists, engineers and others engaged on work involving the use of refractory materials.

Recent Advances in Semi-Conductor Metallurgy. A course of six lectures given by A. S. Abrahams, A.I.M., on consecutive Tuesday evenings at 7 p.m., commencing October 24. Fee £1. Type of student : metallurgists, physicists, electrical engineers and others engaged on research and development work in this field.

Corrosion and Protection of Buried Metals. A course of six lectures, given by specialists from industry on consecutive Thursday evenings at 7 p.m., commencing November 2. Fee 10s. Type of student : metallurgists, chemists, civil engineers and others engaged on work in this field.